Vol. 4 JANUARY, 1921 No. 1

Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

COMMITTEE ON PUBLICATIONS

EDWARD W. WASHBURN, Editor
Ceramics Bldg., Urbana, Ill.

L. E. Barringer, *Chairman*.
General Electric Co., Schenectady, N. Y.

A. V. Bleininger,
Homer-Laughlin China Co., Newell, W. Va.

H. Ries,
Cornell University, Ithaca, N. Y.

E. W. Tillotson,
Mellon Institute, Pittsburgh, Pa.

CONTENTS

Page

Editorials:

Change of Editorship 1
Ceramic Decorative Processes Division 2
Papers for the Columbus Meeting 2

Original Papers and Discussions:

The New Factory of the Monongah Glass Company—Tillotson 3
The Effect of Glaze Composition on the Crazing of Terra Cotta—Hill 25
A Study of Spalling—Howe and Ferguson 32
A Reading List on Vitreous Enameling on Iron and Steel—West 47
Note on Silica Brick—Ross 65

Ceramic Abstracts 68

Activities of the Society:

Actions of the Board of Trustees 82
New Members Received during December 82

Published Monthly by the
AMERICAN CERAMIC SOCIETY
Publication Office: 211 Church St., Easton, Pa.

Entered as second-class matter, July 15, 1918, at the postoffice at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized August 16, 1918.

Copyright, 1920, American Ceramic Society

AMERICAN CERAMIC SOCIETY

OFFICERS, 1920-1921

President: R. H. Minton, General Ceramics Co., Metuchen, N. J.
Vice-President: E. T. Montgomery, Montgomery Porcelain Products Co., Franklin, Ohio.
Treasurer: R. K. Hursh, University of Illinois, Urbana, Ill
Secretary: C. F. Binns, Alfred University, Alfred, N Y
Board of Trustees: The President, Vice-President, Treasurer, and R. D. Landrum, M. F. Beecher, F. H. Riddle, H. F. Staley and R. T. Stull

CORPORATION MEMBERS, 1920-1921

Abrasive Company.
Aexander Hamilton Inst.,
American Dressler Tunnel Kilns, Inc.
American Emery Wheel Works.
American Encaustic Tiling Co.
American Terra Cotta & Ceramic Co.

Bausch & Lomb Optical Co.
Beaver Falls Art Tile Co.
Benjamin Electric Mfg. Co.
Bird and Company
Brick and Clay Record.
Buckeye Clay Pot Co
W. G. Bush and Co.

Canton Stamping & Enameling Co.
Carborundum Co.
Champion Ignition Co.
Colonial Co.
Consolidated Window Glass Co.
Coonley Manufacturing Co.
Cortland Grinding Wheel Co.

H. L. Dixon Co.
E. F. Drakenfeld & Co., Inc.
Dunn Wire Cut Lug Brick Co.
East Liverpool Potteries Co.
Edgar Plastic Kaolin Co.
Edward Ford Plate Glass Co.
Elyria Enameled Products Co.
Findlay Clay Pot Co.
Foote Mineral Co.

French China Co.
Frink Pyrometer Co.
Gillinder Brothers.
Golding Sons Co.
The Glass Worker.

Hall China Co.
Hanovia Chemical & Mfg. Co.
Harbison-Walker Refractories Co.
Harker Pottery Co.
Harshaw-Fuller & Goodwin Co.
Homer Laughlin China Co.
L. J. House Conver Glass Co.

Illinois Glass Co.

Jefferson Glass Co.
Jeffery-Dewitt Co.
Johnston Brokerage Co.
Jones Hollow Ware Co.

Edwin M. Knowles China Co.
Knowles, Taylor, and Knowles Co.
Laclede-Christy Clay Products Co.
Limoges China Co.
A. J. Lindemann & Hoverson Co
Lindsay Light Co.
Los Angeles Pressed Brick Co.
Louthan Manufacturing Co.

Macbeth-Evans Glass Co.
Maine Feldspar Co.
F. Q. Mason Color and Chemical Co.
Massillon Stone and Fire Brick Co.
Maxf Grinding Wheel Corporation.
Midland Terra Cotta Co.
Monongah Glass Co.
Mosaic Tile Co.
D. E. McNicol Pottery Co.
T. A. McNicol Pottery Co.

Nat'l Fire Proofing Co.
Norton Co.

Ohio Pottery Co
Onondaga Pottery Co.
Owen China Co

Pennsylvania Salt Mfg. Co.
Perth Amboy Tile Co.
Pfaudler Co.
Philadelphia Drying Machinery Co
Philadelphia Quartz Co.
Phoenix Glass Co.
Pittsburgh High Voltage Insulator Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Refinance Firebrick and Pottery Co., Ltd.
Roessler & Hasslacher Chemical Co

John H. Sanz & Sons Co.
Saxon China Co.
Sebring Pottery Co.
Smith-Phillips China Co.
Standard Pottery Co.
Standard Sanitary Manufacturing Co.
Star Porcelain Co.
Steubenville Pottery Co.
Streator Clay Mfg. Co.
Square D. Co., Fern, Ind.

Taylor, Smith & Taylor Co.
N. Thomas & Sons Co.
Trenton Flint & Spar Co.

United States Glass Co.
United States Smelting Furnace Co.

Veritas Firing System.
Vitro Manufacturing Co.
Vodrey Pottery Co.

Warwick China Co.
West End Pottery Co.
Western Stoneware Co.

COMMITTEE ON MEMBERSHIP

F. H. Riddle, *Chairman*
Jeffrey-Dewitt Co.
Detroit, Mich.

JOURNAL
OF THE
AMERICAN CERAMIC SOCIETY

A monthly journal devoted to the arts and sciences related to the silicate industries.

Vol. 4 **January, 1921** **No. 1**

EDITORIAL

CHANGE OF EDITORSHIP

For the second time during the existence of the Journal there is to be a change of editors. Dr. E. W. Washburn now succeeds Mr. Homer F. Staley.

Mr. Staley succeeded Mr. Geo. H. Brown, the first editor of the Journal, and has handled all editorial matters in connection with the publication of Vol. 3. Mr. Staley has been progressive in his policies and during his term of office the departments of Ceramic Abstracts and Society Activities have been included and enlarged.

In giving up his work at the Bureau of Standards in Washington and accepting a commercial position, Mr. Staley finds that the new duties will not permit his carrying on the editorial work of the Journal as heretofore and the Board of Trustees has therefore with regret accepted his resignation.

Dr. Washburn comes to the editorial work thoroughly fitted in every way for the position. For some years, he has been at the head of the Ceramic Department of the University of Illinois, and in this position has established a splendid condition of coöperation between the practical clay workers of Illinois and the technical work of the students of the University. Dr. Washburn ranks high both technically and in his conception of the practical problems of the ceramic industry, and the readers of the Journal may look forward to thoroughly well balanced subject matter covering the various phases of ceramic engineering and production.

L. E. BARRINGER

CERAMIC DECORATIVE PROCESSES DIVISION

The annual meeting at Columbus will be marked, among other things, by the first session of the newly organized *Division on Ceramic Decorative Processes.* The Board of Trustees has appointed Mr. Leon V. Solon as temporary chairman, and Mr. Frederick H. Rhead as temporary secretary for the new division. Both these men are well known in the field of artistic ceramics and there is every prospect of their being able to gather a goodly number of interested persons.

The name chosen for the division may be altered. The endeavor was to make it as broad as possible and yet to confine it to the artistic phases of ceramics. This means more than commercial modeling and decoration as carried on in the factory. It should include those who are working in studios and schools with the object of producing or improving wares and methods designed mainly in the interests of beauty.

Sculptors and architects, designers and decorators, archeologists and critics, should all have a share in the new development, and contributions to the program are expected from them and will be welcomed.

PAPERS FOR THE COLUMBUS MEETING

Authors of papers to be presented at the Columbus meeting of the Society are requested to send their manuscripts to the editor before the meeting, and *as soon as possible,* in order that the March number of the Journal may not be delayed. Manuscripts received before the meeting will be given preference over those received later.

ORIGINAL PAPERS AND DISCUSSIONS

THE NEW FACTORY OF THE MONONGAH GLASS COMPANY

By E. Ward Tillotson*

Historical

About twenty years ago, food packed in glass jars with vacuum-seal tops became an article of commerce. This step was one of great importance to both the food packing industry and the glass industry, not only because of an extension of the uses for glass, but especially because the difficulties which were encountered stimulated the development of mechanical devices which should produce a more uniform and perfect article of glass than was possible by hand production.

For the successful use with the vacuum-seal, the glass tumbler or jar was, and is, required to be well nigh mechanically perfect. The top upon which the cover fits must be of accurate dimensions and not be distorted and, further, must be smooth and without the irregularities caused by "overpressing" or "underpressing" too much or too little glass. This irregularity in the quantity of glass is unavoidably large where glass is gathered by hand, and is further a source of annoyance by reason of the variations in the capacity and weight of the product. One factory, the Rochester Tumbler Co., Rochester, Pa., was able with care to turn out, in quantity, glass containers which met the exacting requirements. However, this was accomplished only by the aid of selected workmen and by exercising scrupulous care, especially in the final inspection of the product.

*Received July 3, 1920.

The superintendent of this factory, Mr. H. L. Heintzelman, who had been responsible for this successful production, clearly foresaw the future growth of this type of glassware and resolved to build a factory primarily to produce glass tumblers from continuous tanks. Associated with Mr. Heintzelman in this industry was Mr. William Moulds, now deceased, General Manager of the Rochester Tumbler Company, and a glass maker of long experience and high ability. Prior to this time, the better grades of glass were made in covered pots. The continuous tank had been in use since 1879 and, subsequent to the introduction of natural gas, had come into favor for the manufacture of window and bottle glass. The production, therefore, of a high grade of "crystal" in continuous tanks marked an important advance in glass technology. It was the result of the use of the best of raw materials and of constant personal attention on the part of men who through years of experience and of constructive observation had evolved an idea typically American and who possessed the courage and energy to carry it to a successful conclusion.

At that time natural gas was established as a fuel for melting glass and accordingly a location for the new enterprise was selected with this as an important consideration. Fairmont, W. Va., was well situated with respect to fuel and to transportation, and, furthermore, was a city in which the workmen would be content to live. Therefore, Fairmont was selected as the site of the new factory and the Monongah Glass Company received its charter under the laws of West Virginia on December 29th, 1903. Construction of the factory was commenced on April 18th, 1904, and the first glass was produced on August 18th of the same year. The buildings were of the cheap frame construction which, until recently, has characterized glass factories, and housed two 12-ton continuous tanks, each having eight rings. The capacity of this factory expanded rapidly: within two years a new factory was built especially to produce blown tumblers and stemware from lead glass. The use of vacuum-seal glass containers for foods increased, and it became evident that hand production not only would be unable to keep pace with the demand; but also, by reason of the special skill required on the part of the workmen, the prospect of a limited number of men of the necessary skill directed

attention to the development of a mechanical device which would take the place of human skill and allow of a production which would not be limited by the personal equation. Accordingly, in 1910, and in coöperation with the Beechnut Packing Company and the engineering firm of Wm. A. Lorenz & Company, Hartford, Conn., the development of a mechanical feeder and an automatic press was commenced. These devices, which are controlled by the Hartford-Fairmont Co.,[1] have during the past two years entirely supplanted the hand-presses at the Monongah Glass Company for the production of packers, tumblers and jars. The feeder has found an increasing usefulness in other factories for the manufacture of both wide and narrow mouthed bottles, milk bottles, lantern chimneys, and incandescent lamp bulbs. At present there are eight feeders installed at Fairmont and about sixty in other factories; the total capacity is 200,000 tons of glassware per annum.

During the development of these devices, they were used in connection with furnaces which already had been built and in factories which had been designed for hand-production. This, while successful, was recognized as being far from the ideal situation. It was determined that a new factory should be built in which all parts should be correlated to bring about the most favorable conditions for the mechanical production of pressed glassware, and it was resolved further that this should be no temporary structure of cheap construction but should be built in accordance with modern factory construction as a permanent house for these newly successful machines. This new factory was constructed during the latter part of 1918 and was put in operation on April 1, 1919. It is designed to contain two 50-ton tanks, each with four Hartford-Fairmont feeders and four Hartford-Fairmont duplex presses. At present, only one tank has been built, the second one waiting on any changes in design or arrangement that may prove advisable. There is also some machinery to be installed, and an auxiliary building for the transformers and for an addition to the machine shop and mold room is planned for the near future.

This new factory, therefore, is worthy of note by reason of its

[1] A company of the State of New York of 1912.

being of expensive[1] and permanent construction, by reason of the high quality of glass produced in the continuous tanks, and by reason of the efficient design and arrangement which allow of mechanical production in the greatest degree. Indeed, the writer considers it a privilege that he has been permitted to secure intimate data with respect to this factory for presentation in THIS JOURNAL. So far as the writer knows, this is the first detailed description of an American glass plant to be made public, and this fact certainly marks a new and laudable attitude on the part of the American glass manufacturer.

The Buildings

The buildings of the new plant of the Monongah Glass Company are of the well known reinforced-concrete type of factory construction. The warehouse and factory, which are adjacent to each other, total 161 ft. 6 in. in width and 270 ft. 10-½ in. in length, and extend in the north and south direction (see figure 1). The

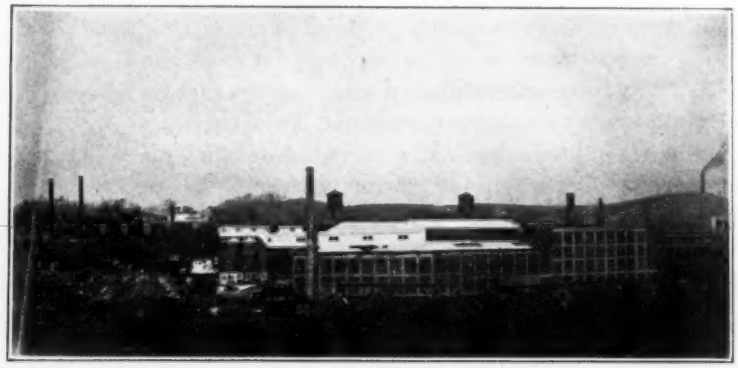


FIG. 1.—The new factory of The Monongah Glass Co. (looking northwest). At the extreme left are buildings of the old plant.

factory, which contains the tanks, presses and leers, is 161 ft. 6 in. by 160 ft. 9 in. and is located at the south end of the warehouse. The factory floor is on a level with the first floor of the

[1] This complete unit represents an investment of between $700,000 and $800,000.

warehouse and in direct communication with it (see figures 2 and 3). The walls of both buildings are described as being 9-in. curtain walls, extending three feet above the floor, the balance of the walls being taken up by windows.

The Warehouse.—The warehouse contains a basement and three floors of the following heights, measured from floor to floor: basement, 13 ft.; first floor, 14 ft.; second floor, 13 ft.; and third floor, 12 to 18 ft. The floors are flat slabs of reinforced concrete and are designed to support a load of 350 pounds per square ft. The surface of the floors are hardened with "Lepidolith" hardener. The columns are cylindrical and form eleven bays of 18 ft. 10 in. centers and ten bays of 16 ft. centers. The building is equipped with "United States" steel sash and ventilators, and the monitor in the roof, which extends lengthwise of the building, is equipped with operating sash. The roof of the warehouse is of reinforced concrete and is finished with Barber's asphalt roofing.

The warehouse contains two freight elevators, 8 ft. by 12 ft. 6 in., which are driven by electric motors, and operate between the basement and the third floor. The main stairway is located in the northeast corner of the building and is of concrete. An additional stairway is provided at the north end of the warehouse near the center, and an outside fire-escape at the northeast corner of the building. Ample toilet accommodations are provided on each floor, and the Fairmont Box Company occupies office rooms on the second and third floors.

The partition between the warehouse and factory on the second floor consists largely of windows which give opportunity for inspection of the factory from this floor, and also allows the heat from the factory to be utilized. The building is heated by direct radiation by steam, which is generated at a central boiler plant located at the northeast end of the factory and which supplies heat for the entire plant. The warehouse is also equipped with adequate water, gas and sewage plumbing, and is protected from fire with the sprinkling system of the General Fire Extinguishing Company. The electric wiring is all contained either in steel conduit embedded in concrete or is supported on the steel structure of the building. Separate panels are provid-

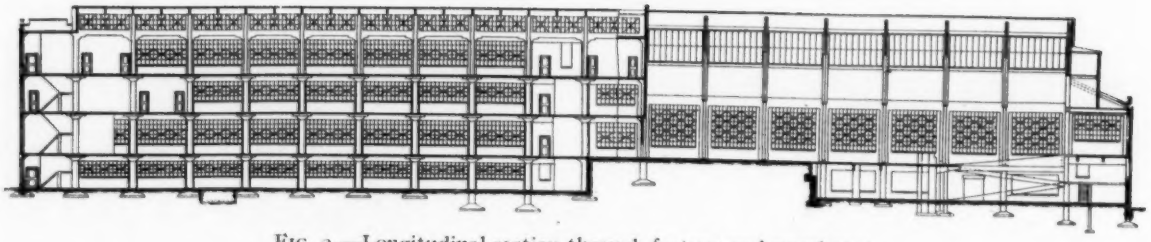


FIG. 2.—Longitudinal section through factory and warehouse.

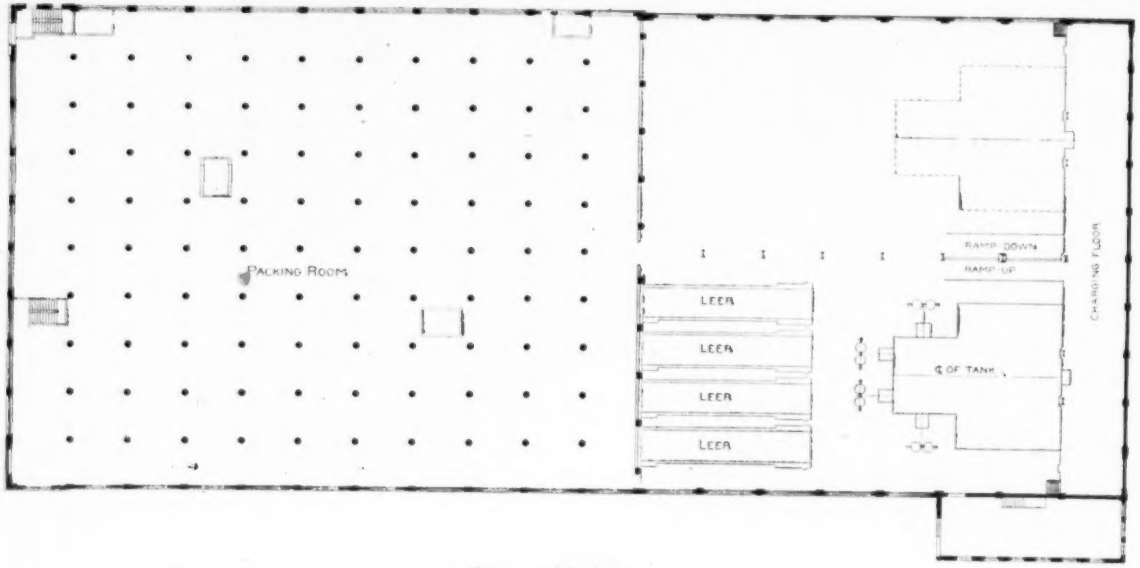


FIG. 3.—First floor.

ed on each floor for light and power. The main transformers consist of three 100-K. V. A. transformers, located in an enclosure in the basement of the compressor room, and are connected with the 2200-volt power mains. It is planned, however, that in the near future an outside substation will be installed which will contain three 250-K. V. A. transformers connected with the 22,000-volt power mains.

Only the first and second floors of this building are used for the warehouse proper. The basement and third floor are largely employed by the Fairmont Box Company for the manufacture of corrugated-fiber board and corrugated-fiber board boxes, in which the glassware is packed for shipment. The board is manufactured in the basement and the boxes are formed on the third floor. From the third floor, the boxes are delivered into chutes, through which they pass to the second floor, and then are placed on roller gravity conveyors, by which they are directed to the desired point. On this floor there are eight hatches, one for each leer. The chutes leading from these hatches are at an angle of about 30°, terminating at the bottom in a horizontal section, about 10 ft. long and directly over the leer. This arrangement, therefore, represents an economy of space and brings the boxes directly to the hands of the "selector," who fills them with glass from the leer.

Fig. 3.—First floor.

Scrap chutes of galvanized iron, about 2 ft. by 4 ft. in dimensions, are provided for conveying waste material of the box manufacture from the third floor to the basement. These chutes have openings on each floor.

The Factory.—The factory building contains one floor on a level with the first floor of the warehouse and connected with it, and a basement. The factory basement floor is slightly above the level of the warehouse basement but is not connected with it.

The factory roof is supported by nine steel trusses spanning one-half the width of the building, with a slope of one-half pitch. At the top of each ridge is a steel monitor extending the length of the building with the exception of one bay, which is occupied by the batch conveying system (see figures 1 and 4). Each monitor is equipped with two courses of "United States" top hung sash,

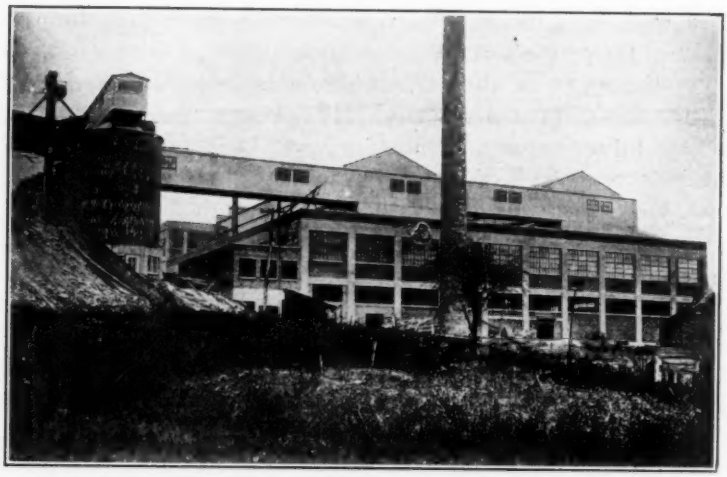


FIG. 4.—Factory building (looking northeast).

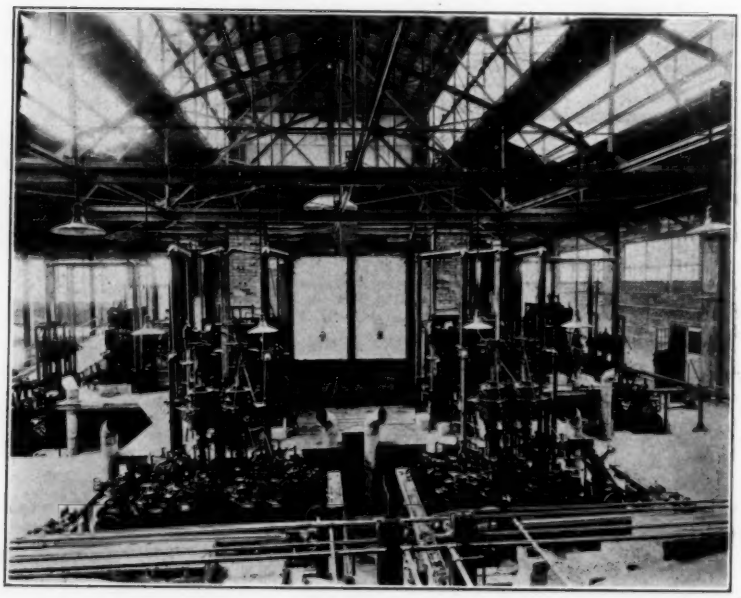


FIG. 5.—Machines.

operable from the factory floor by chains (see figure 5). Extending across the building, on the plant end, is a steel gallery carrying the belt conveyors for bringing the glass batch to the furnace bins. This gallery extends over a bridge to the batch storage-bins just west of the building (see figure 4). The factory roof is of corrugated asbestos sheet roofing supplied by the Keasby & Mattison Company. The gallery also is roofed and sided with the same corrugated material. Directly above the machine presses and above the rear end of the leers are spaces in the roof, 8 ft. by 20 ft., fitted with sheets of corrugated wire glass[1] to match the asbestos roofing (see figures 5 and 6).

At the south end of the basement, extending across the end of the building, is a mezzanine floor, 12 ft. 10 in. wide and 7 ft. above the basement floor. This is connected with the basement floor by a concrete ramp, 8 ft. wide, and with the first floor level by a similar ramp. Extending across the south end of the building, 4 ft. 4 in. above the main floor, is the charging floor which is connected with the main floor by a third ramp. The main floor is built to within two feet of the tank walls and is supported by special columns from the basement to accommodate the machine presses, furnaces, etc.

The factory is designed to accommodate two 50-ton continuous tanks, but at the present time only one of these has been completed. This tank is of the well-known type designed by H. L. Dixon. The melting compartment is 20 by 32 ft. inside and the refining end is 20 by 14 ft.; the walls are 12 in. in thickness. It is equipped with five ports on each side and with regulators for both air and gas. The melting capacity is 50 tons per 24 hours. The one uncommon feature about this tank is its unusual height above the working floor (7 ft. 5 in. from the working floor to the metal line); this was made necessary in order that the feeder and press might be operated conveniently. The metal in the tank is about 41 in. in depth.

On the nose of the tank are two forehearths on 14 ft. centers, which extend 7 ft. 9 in. from the tank wall, and on each side of the furnace at approximately the middle of the working end is also located a similar forehearth. These forehearths are con-

[1] Manufactured by the Pennsylvania Wire Glass Company.

structed of special shaped fire-clay blocks and are insulated with "Nonpareil" cork brick, and each contains one of the Hartford-Fairmont feeding devices. The forehearths are heated by high

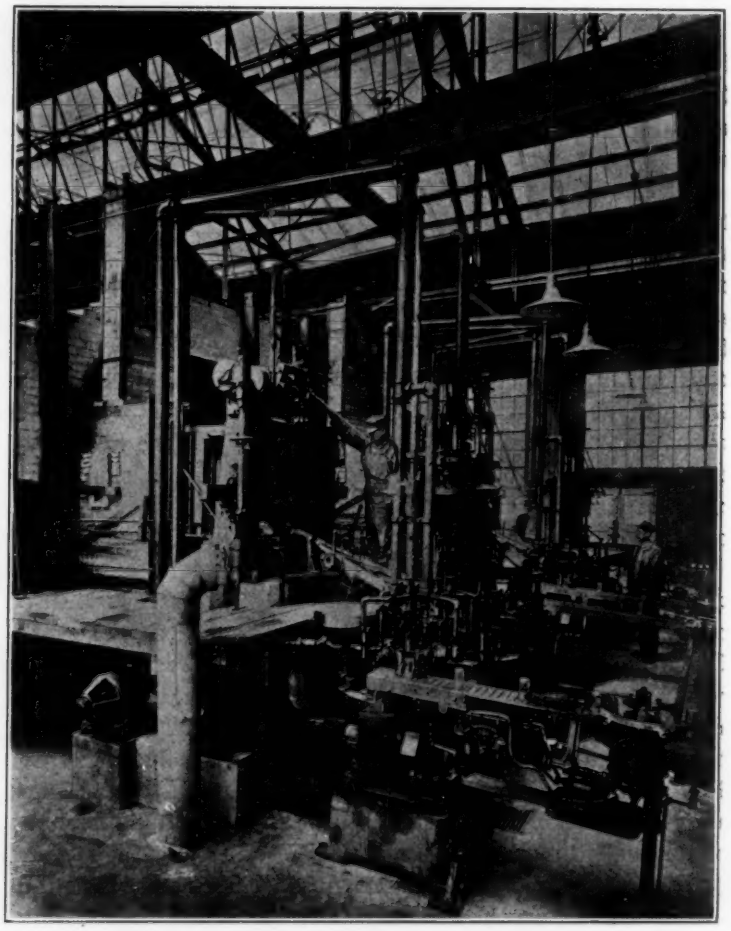


FIG. 6.—Two machines at nose of tank.

pressure (15 to 20 lbs.) natural gas. The tanks are designed to use producer gas and each requires about 210,000 cubic ft. of 125 B.t.u. gas per hour.

The Hardford-Fairmont Feeder

The principal operating feature of the Hartford-Fairmont feeder consists of a moving paddle,[1] which forces a quantity of the molten glass over a fire-clay dam. The glass then flows through an opening in a fire-clay ring, thus forming a "gather" of suitable size and shape for the pressing operation.

Figure 7 shows a longitudinal section of the feeder. *A* represents

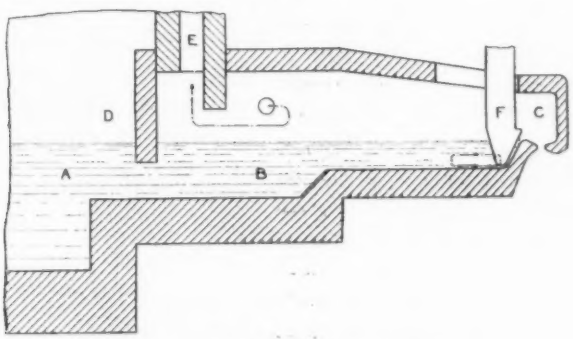


FIG. 7.—Hartford-Fairmont feeder.

the working end of the glass tank. *D* is a fire-clay partition dipping below the level of the glass and acting as a skimmer to remove bubbles or insoluble material floating on the surface of the glass. From *A* the glass flows under *D* and into the chamber *B*, which consists of a channel, 12 in. wide, narrowing to a width of about 6 in. at the extreme end. *F* is the paddle which operates within this channel, forcing a portion of the glass at each stroke into compartment *C*, where it falls through the opening as indicated. A pair of knives operate directly beneath and close to this opening, shearing off each "gather," which falls into a trough and is conveyed to the mold.

[1] See U. S. Pat. 1,328,799, Jan. 20, 1920, Karl E. Peiler;
See also U. S. Pats. 1,277,254, Aug. 27, 1918, Karl E. Peiler;
1,277,255, Aug. 27, 1918, Karl E. Peiler;
1,277,256, Aug. 27, 1918, Karl E. Peiler;
1,324,464, Dec. 9, 1918, Karl E. Peiler;
1,328,799, Jan. 20, 1920, Karl E. Peiler;
1,332,405, Mar. 2, 1920, Karl E. Peiler.

The paddle is driven by a mechanism which is connected directly and synchronized with the press which it feeds. The path traveled by the paddle may be described as that of a distorted ellipse. At the end of each stroke it is raised slightly and then is carried back in a nearly straight line, after which it is lowered and travels forward in a substantially straight line. At all times it dips beneath the surface of the glass, a condition which is necessary in order to prevent the introduction of air bubbles through a churning action. Both the "dip" and the stroke of the paddle may be regulated. The stroke ordinarily varies from four to six inches and is determined by the weight of the article which is to be made. It is, therefore, a permanent adjustment. The dip below the surface of the glass varies from two to four and one-half in., and the distance between the upper and lower path of the paddle is approximately one and one-half in. The quantity of glass delivered by each stroke may be regulated while the machine is in motion by raising or lowering the paddle, thus varying the dip. The provision is necessary in order that the amount of glass discharged may be kept constant in spite of variations in the level of the molten glass and that the effects of unavoidable temperature fluctuations in the channel may be balanced. This is controlled by a hand-wheel within easy reach of the press attendant. The paddle is of fire-clay, about five in. wide and shaped to fit closely the channel at the end of the stroke. The paddle has an average life of two months.

The fire-clay ring through which the glass is discharged and which forms the glass into a shape suitable for pressing, is contained in a metal frame and allows of easy removal and replacement. It has been mentioned that the quantity of glass delivered is determined by the stroke and the dip of the paddle. In extreme cases this may be adjusted to deliver from $^3/_8$ oz. to 42 oz. of glass. In practice, however, the range is between 1 oz. and 32 oz. The iife of the glass outlet ring is approximately one month and ten minutes are required for the insertion of a new ring.

The channel B is heated by means of high pressure natural gas through burners in the side walls. The products of combustion follow the course indicated by the arrow, passing under the clay baffle and out the flue E into the stack. The temperature of

the glass in the nose of the tank (*A*) is approximately 2050°F. and in the channel (*B*) is approximately 1950°F. The paddle delivers through the outlet ring *C* just enough glass for one of the articles which is being pressed. It is necessary, however, to separate the drop so formed from the small amount remaining in the outlet and this is accomplished by two V-shaped knives[1] of carbon steel acting close to the outlet. These knives are actuated by a mechanism connected directly with the rest of the machine, and, of course, are synchronized with it. Their action is almost instantaneous and their V-shape results in eliminating the "shear mark" on the pressed piece. After being severed, the glass drops into a trough inclined at an angle of about 30° from the horizontal. This trough is of metal and is lined with a porous carbonaceous material which is kept moist by a small stream of water. The glass, therefore, slides down the trough upon a film of water vapor without sticking and without showing differential cooling.[2]

Each feeder supplies 2 presses[3] which carry 8 molds each. The trough above mentioned is composed of 3 sections, the upper one of which is pivoted and is caused to swing so that it delivers glass alternately to each of the presses. From the lower section of the trough the glass is delivered into a funnel, which directs it into the mold. Each revolving mold table carries 8 molds. As the table revolves, it halts momentarily at 8 stations, at which the following operations take place:

(1) The glass drops into the mold.
(2) The pressing operation is performed.
(3) and (4) The pressed article is cooling and "setting."

[1] See U. S. Pat. 1,326,460, Dec. 30, 1919, Wm. A. Lorenz.
[2] See U. S. Pat. 1,199,108, Sept. 26, 1916, Karl E. Peiler;
U. S. Pat. 1,264,328, Apr. 30, 1918, Karl E. Peiler;
U. S. Pat. 1,300,180–1, Apr. 8, 1919, Wm. A. Lorenz.
[3] See U. S. Pat. 1,259,280, Mar. 12, 1918, Karl E. Peiler;
U. S. Pat. 1,259,281, Mar. 12, 1918, Karl E. Peiler;
U. S. Pat. 1,291,952, Jan. 21, 1919, Wm. A. Lorenz;
U. S. Pat. 1,292,033, Jan. 21, 1919, Karl E. Peiler;
U. S. Pat. 1,316,550, Sept. 16, 1919, Karl E. Peiler and E. H. Lorenz;
U. S. Pat. 1,331,471, Feb. 17, 1920, Karl E. Peiler and W. A. Lorenz;
U. S. Pat. 1,331,472, Feb. 17, 1920, Karl E. Peiler and E. H. Lorenz.

(5) The article is taken out of the mold.

(6) (7) and (8) The mold is cooled preparatory to receiving the new charge of glass.

At station 8 the mold ring is raised and swung over a gas burner to maintain it at the proper working temperature. The press plungers are operated by compressed air at 40 lb. pressure and exert an estimated pressure of 4000 lb. to the sq. in. This pressure may be regulated by the attendant (through a crank within easy reach; see figures 5 and 6). The plungers are hollow and are water-cooled. It is estimated that the average temperature of the surface of the mold is 600°F. and of the plunger 800°F. The presses and feeder are all driven by a 3-horsepower motor and are all operated from one shaft. In practice, 1 feeder with 2 presses is capable of turning out 44 pieces per minute of 4 oz. in weight, or 36 per minute of 12 oz. in weight. The cost of one unit as described above is approximately $15,000.

The advantages which are claimed for this device consist in an article of more uniform weight, the weight being controllable within 2 per cent; a greater production and full operation during the 24 hours in three shifts, and ware of better quality. At present 60 of these feeders are in operation throughout the country and are employed in the making of bottles, both narrow and wide mouth, bulbs for incandescent lamps, and a variety of other products.

At station 5, the article is removed from the mold by a plunger, operating vertically, which raises the article above the top of the mold. At this point it is seized in a metal frame operating like a pair of hands. This device, which swings in a vertical arc, is actuated by the same mechanism which operates the press. By its action the ware is inverted and placed upon an iron plate and released, and a lever then pushes the article on to the automatic conveyor, which carries it to the leer.

The conveyor which automatically carries the ware to the leer, and also automatically introduces the ware and distributes it in the leer, is the well known mechanism of the Automatic Machinery Company, of Terre Haute, Ind. It is, however, supplemented by features developed by the Hartford-Fairmont Company, which prevent sudden cooling of the glass with the attendant

troubles from chipping and breakage during its course to the leer. The particular addition consists of a tunnel formed of material of low thermal conductivity which is built over the conveyor and through which the ware passes.

The leers are of the Steelman muffle type and were designed by Mr. H. L. Dixon. One leer is provided for each machine. They are 60 ft. long and 10 ft. wide in the clear, and the pan is operated continuously by a variable speed direct-current motor. This speed of the leer pan may be varied from 3-½ in. to 6 in. per minute. The heating end of the leer is 11 ft. 9 in. long and 30 in. high from the pan to the arch. The roof then slopes during a distance of 4 ft. 3 in. to an average height of 10 in. above the pan, and was so designed as to prevent a general distribution of the hot gases throughout the leer by reason of convection currents. The heating end is insulated with "Nonpareil" cork brick and this lagging also extends over two arches of the cooling end. The leers are heated with producer gas. The burners are placed at the sides and below the leer, and the hot gases travel through 9 by 6 in. flues in three up-comers and three down-comers on each side of the leer. The air employed in the burners is heated in a recuperator, through which the hot waste gases pass.

Some modification of the leer has been made to better accommodate it to the use of producer gas and to adapt it for the automatic devices. One of these is an extra burner which has been located under the pan at the filling end to maintain the desired temperature at this point. Each leer consumes about 12,500 cu. ft. of producer gas per hour.

The producer gas, which is furnished by the Monongahela Valley Traction Company, is manufactured in a system of Lymn producers located near the north end of the plant. It is conducted to the factory through a 33-in. riveted pipe of $^{3}/_{16}$-in. steel. This main pipe line is about 1100 ft. in length and from the end a 24 in. spiral riveted pipe leads to the furnace and a 12-in. pipe brings the gas to the leers.

The gas reversing valve is the Wellman-Seaver-Morgan 30-in. Forter valve. The air reversing valve is of the Siemen's type.

The average composition of the producer gas is as follows:

Carbon dioxide	15–16	per cent
Carbon monoxide	6–8	per cent
Hydrogen	18–21	per cent
Oxygen	0.7–0.8	per cent
Methane	2.5–4.0	per cent
Unsaturated	0.6–0.9	per cent

The average calorific value of this gas is 125 B.t.u. It is received at the factory at a pressure of 3-½ oz. and at a temperature of about 100°F.

Air for chilling the pressed ware in the molds and for cooling the feeder paddle and blowing out chips from the molds is provided at 3–½ lb. pressure. This is supplied by three General Electric centrifugal compressors with a total capacity of 8 machine presses, with a No. 8 Sturtevant blower held in reserve. The ducts carrying this air are of heavy galvanized pipe and are all underground.

For operating the presses and the automatic unloading devices, air is supplied at 40 lb. pressure. This is provided by one Ingersoll-Rand compressor, belted type, 17 in. by 12 in., and operated by a 70 horsepower motor. It is planned to install a second unit of the same type and also two Ingersoll-Rand compressors, 14 in. by 10 in., of the same type, and each operated by 40 horsepower motors. The high pressure air is carried through overhead steel pipes.

These blowers are located in an auxiliary room of two stories on the south west corner of the factory, 61 ft. 1–½ in. by 21 ft. 3 in. in dimension.

The water system which provides for the cooling of the presses and the plungers of the machine presses is the city water which is raised to 75 lb. pressure by a centrifugal pump. This cooling water is collected and stored in the 2000-gallon reservoir for later use. It is planned that a spray system be installed for cooling this water.

The air used in cooling the tanks and men is supplied by the 150-in. Garden City, three-fourths housed bottom-discharge blower, operated by a 50 horsepower motor at 300 R.P.M. From this blower the air passes into an undergound duct of concrete, 5 ft. by 4 ft. in cross-section. Branch ducts at an angle of about

45° to the main duct lead to the machine presses and the furnace. The air duct leading to the furnace is 36 in. sq. and branches into the working end of the furnace in two ducts, 24 in. square, extending underground on both sides of the furnace. From these ducts 10 in. galvanized pipes conduct the air to the vent pipes of the furnace. These vent pipes are divided into 3 closed-end sections of 2 courses each. Each section is 9 ft. 6 in. long, of reinforced galvanized iron, carrying a slot varying in width from $^1/_4$ in. at the center to $^3/_8$ in. at the end of the section (see figure 8).

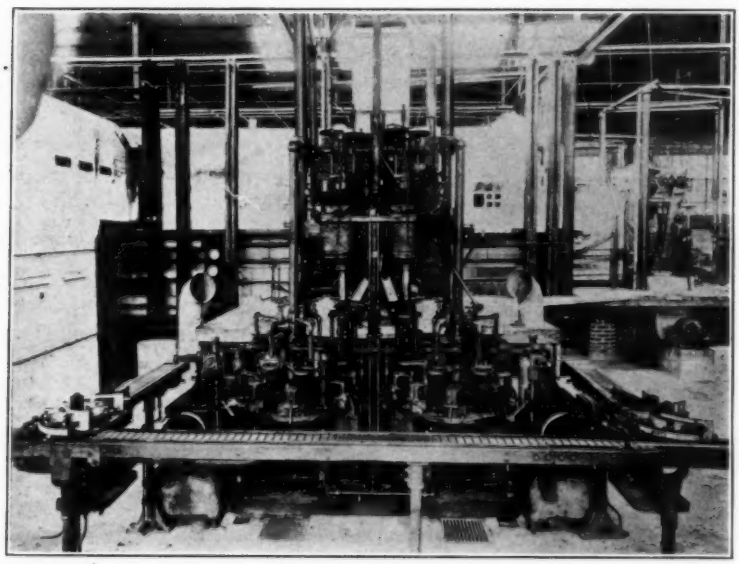


FIG. 8.—Machine at side of tank.

The vertical risers are of 10-in. steel pipe from the concrete duct to a height of 4 ft. above the floor, to protect the system in case of an emergency.

The air is supplied at a pressure of from 2–½ to 3 in. of water. The underground concrete duct bottom is built over a uniform gradient from the extreme end to the fan bed, so that the water will flow toward the fan and through the trap to the sewer. Each vertical 10 ft. duct is equipped with a blast-gate valve.

To provide for the comfort of the workman, each machine system is equipped with 6 of these 10-in. pipes (see figures 5, 6 and 8), connected with the air system. Four of these terminate in cast-iron floor grids, and two of them are carried above the feeder platform and are provided with "turn-heads" which may be turned in any direction.

The Batch System

Opposite the south end of the factory and to the west are 5 storage bins near the railroad track. They are 20 ft. inside diameter and 28 ft. high to the bottom of the roof cone and each is designed to hold 10 carloads of materials. The walls, which are 6 in. thick and are constructed of Wiederholdt patent clay tile, have lateral reinforcements in every 12-in. course and vertical reinforcements on 21-in. centers. The reinforcing rods are embedded in concrete which fills the hollows of the concrete block. The conical roof is supported on steel rafters covered by "hyrib" reinforcing and is of concrete 3 in. in thickness. The slope is about 30°. At the top is an opening two ft. in diameter, through which the material is delivered to the bins. The bins are supported on a reinforced concrete foundation capable of supporting a load of 3,000 lb. per sq. ft.

Bins 1 and 2 are used for the storage of sand, and bins 4 and 5 for soda ash. The central bin, 3, is built with 3 compartments, for cullet, lime and the mixed batch, respectively.

The raw materials are unloaded from the car by a Clark shovel into a hopper adjacent to the central bin. From this hopper the material passes through a chute into the elevator boot, and from there it is lifted to a point about 30 ft. above the storage bin, where it is delivered into a chute which directs it on to a 20-in. shuttle belt conveyor (see figures. 1 and 4). This conveyor is protected by a steel gallery extending the whole length of the bin system. The belt conveyor is reversible and is one-half the length of the gallery, so that any bin may be filled from it.

The elevator is of the belt-bucket type equipped with 10 in. by 6 in. buckets and is used for elevating both the raw materials and the mixed batch. At the head of the elevator is a 2-way

gate for discharging the material to the main conveyor or to the shuttle conveyor.

Extending westward from the storage bins is a second gallery of wood, 280 ft. long, which supplies 4 furnaces in the old factory building. This has a 16-in. belt working on 265-ft. centers, and the material is discharged from it by a mechanical tripper.

On the east side of the central storage bin is located a second elevator which carries the mixed batch to a 16-in. belt conveyor in the steel gallery which leads to the new factory.

Nine ft. two in. below the bin floor is the mixing floor. This extends the entire length of the bin system and is equipped with a 4 ft. gauge track, which carries the weighing and mixing car.[1] The raw materials are discharged into the weighing car through duplex gates in the bottom of each bin. The car is of two tons capacity. After mixing, the batch is discharged through track hoppers into the central bin and then is conveyed by a horizontal screw conveyor into either elevator. The car is driven electrically by the 15-horsepower motor for driving the mixing drum, which is 6 ft. in diameter and 4 ft. long.

Two batch bins,[2] which are located over the furnaces and from which the batch is charged into the tanks, are 9 ft. 3 in. square and 11 ft. in effective height. Each contains a 24-hour supply of batch for its furnace. The bins are provided with a pyramidal cover of 45° slope, and the bottom slopes three ways at about 45°. The bins are constructed of $^1/_4$-in. steel and the bottoms are heavily ribbed with angle iron and reinforced with stay bolts. The bins are suspended from the steel structure of the building.

The Batch.—The batch employed in this factory is as follows:

Sand	2250 pounds
Soda	900 pounds
Lime	240 pounds

In addition, there is added a small quantity of a selenium-cobalt decolorizer which has been worked out to meet conditions prevailing in this factory.

[1] This equipment as well as the elevators and belt conveyors was furnished by the Stephens-Adamson Company.

[2] These bins were furnished by the Moss Iron Works, Wheeling, W. Va.

The sand is from Berkley Springs, W. Va., and carries about 0.07% of iron. The lime is from Seneca County, Ohio, and is a highly dolomitic lime; it is used in the burned and ground condition. The soda is the usual dense 58 per cent ash.

Proofs are taken twice each day at both the working and melting ends. The temperatures maintained in the tank are somewhat dependent upon the amount of glass being worked, but on an average are about 2250° F. at the melting end and 2050° F. at the working end. The leers are maintained at about 1000° F., but this temperature is somewhat dependent upon the size of the ware going through.

The Stacks

Each furnace is equipped with the well known stack constructed by the Weiderholdt Construction Company, of St. Louis. These stacks are 5 ft. in internal diameter and 110 ft. high. The first 60 ft. is lined with fire-brick. The stacks are constructed of the patent hollow tile reinforced with ½ in. horizontal steel rings in each 10-in. course and with 1 in. reinforcing rods on 21-in. centers from top to bottom. At the base, these vertical reinforcing rods spread outwards, like the roots of a tree, in a concrete base. The base is of concrete, 16 ft. square, and rests on a secure shale foundation. It is 8 ft. in depth.

Each leer has a separate 24-in. steel stack lined with fire-brick, reaching above the roof of the factory. They are, therefore, about 35 ft. in height.

The Laboratory

The laboratory is located on the second floor of the warehouse building, adjacent to the factory. It, therefore, commands, through the windows in the partition wall, a view of the interior of the factory building. The laboratory is approximately 30 ft. by 60 ft. and is equipped with materials and apparatus for analytical and control work. Within the laboratory also are recording pyrometers connected with thermocouples in the furnaces and leers. Each furnace contains a platinum-platinum rhodium couple in the melting end and one in the refining end. Each leer is equipped with a base-metal couple[1] in the hot end of the leer.

[1] These couples are all compensated for the cold junction and were furnished by the Brown Instrument Company.

Behind the furnace on the charging floor there are indicating instruments for the convenience of the furnace man, and there are also indicating instruments by the leers. Behind the furnace there is installed a Frink recording draught gauge, and on the main gas line a pressure gauge for the convenience of the furnace man.

In the laboratory raw materials are subjected continually to chemical control, the lime especially being given close attention.

Selection and Packing of the Ware

At the cold end of the leer the ware is subjected to a most searching inspection. By reason of the fact that this ware is used in connection with vacuum sealed tops, it is necessary that every piece shall be mechanically perfect. Gauge rings therefore are provided, to which each piece must conform.

Samples also are taken every two or three hours and examined in the scleroscope for strains resulting from imperfect annealing. Similar samples also are tested by immersion in boiling water, and, when thoroughly heated, by plunging into cold water. All ware showing defects such as blisters, seeds, mold marks, plunger marks, over or under pressing, checks, chips and leer marks, is rejected summarily and is returned to the cullet bin. To facilitate the handling of this cullet there is provided a 4-ft. concrete duct extending across the selecting end of the leer in which a belt conveyor will be installed, which will carry the cullet to the second conveyor extending the length of the plant, and conveying the cullet to a receiving bin in the factory.

The products of this factory consist of a standard line of "packers", such as "jellies", "peanut butters", "mustards", etc., with an average range of capacity from 4–$^1/_4$ oz. to 16 oz. The ware is placed in corrugated boxes at the annealing end of the leer, and, with the aid of platforms and elevating trucks, is put in storage or is loaded into cars. Each box contains from one to three dozen pieces, depending upon the size of the pieces, and about ten thousand boxes[1] are packed per day.

[1] This corresponds to about 3 carloads, with an average of 2500 to 4000 boxes per car.

Summary

This new factory, constructed in 1918–19, is worthy of note by reason of its expensive (7 to 8 hundred thousand dollars per unit) and permanent construction, by reason of the high quality of glass produced in continuous tanks, and by reason of its efficient design and arrangement and the extensive employment of mechanical devices throughout. This paper gives a detailed description of the factory under the following headings: Historical; Buildings, Warehouse, and Factory; The Hardford-Fairmont Feeder with description operation; The Batch System and the Batch; The Stacks; The Laboratory; and Selecting and Packing the Ware.

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
OF THE UNIVERSITY OF PITTSBURGH,
PITTSBURGH, PA.

NOTICE—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

THE EFFECT OF GLAZE COMPOSITION ON THE CRAZING OF TERRA COTTA[1]

By E. C. Hill

The occurrence of crazing on terra cotta is due primarily to the composition of the body, engobe and glaze used. If the compositions used are such that crazing may result, the probability of crazing occurring will be increased by rapid cooling, immature firing and applying the glaze and engobe in a heavy coat. These conditions may be considered of secondary importance however, and if the compositions of the body, glaze and engobe are properly proportioned, these conditions will not cause crazing.

The composition of the body has a considerable influence on the occurrence of crazing. It has been found, in testing clays for use in a terra cotta body that the fat, plastic clays are generally more likely to produce crazing than the less plastic, more sandy ones. The very sandy clays have been found to produce shivering. A certain amount of fat, plastic clay is essential in a terra cotta body. The varied requirements of a good body, however, are such that it would seem poor practice to depend on changing the composition of the body to any extent to control crazing; and whatever changes are necessary to prevent crazing should be made in the englobe and glaze.

The composition of the engobe also has a considerable influence on the occurrence of the crazing. Stull,[2] in an investigation of the properties of enamel brick slips, covered a wide field of compositions and found quite definite relations between the composition of engobes and the occurrence of crazing. Briefly, his conclusions regarding crazing may be stated as follows. A high content of flint in the engobe causes crazing and it may be overcome by substituting clay or feldspar for flint, the former being the more effective. A high content of clay overcomes crazing in the engobe, but causes the glaze applied over it to craze. Substituting

[1] Received February 27, 1920.

[2] *Trans. Amer. Ceram. Soc.*, **12**, 711.

feldspar or flint for clay, reduces crazing in the glaze. It is evident then that the composition of the engobe should be such that there will no tendency for it to craze itself, or cause the glaze applied over it to craze.

The object of the work undertaken in this study was to determine the effect of the composition of the glaze on the tendency to craze, and, as far as possible to determine whether each component as it was added to the glaze, tended to produce or overcome crazing.

Experimental

The body used was composed of equal parts of fat plastic clay that had shown a tendency to produce crazing and one which might be considered medium in this respect. The body contained 35% grog. The trials, 8 by 8 by 2 in., with a heavy egg and dart ornament on the side, were pressed from this body. When dry, the test pieces were sprayed with the engobe regularly used and over this a heavy coat of glaze. They were fired in a small 6 ft. test kiln to cone 5½ in 40 hours and cooled in about the same time. Two burns were made and three trials of each glaze were fired in each burn. The composition of the body, the thick coat of glaze and the rapid cooling were depended upon to produce crazing in those trials where that tendency existed.

In a study of the effect of glaze composition on the fusibility[1] made by the writer the most fusible glaze produced was:

$$\begin{matrix} 0.40\ K_2O \\ .30\ CaO \\ .30\ ZnO \end{matrix} \quad \begin{matrix} 0.45,\ Al_2O_3 \end{matrix} \quad \begin{matrix} 3.25\ SiO_2 \\ .10\ SnO_2 \end{matrix}$$

It was decided to use this glaze as a basis for this study, but to introduce 0.10 eq. MgO and 0.20 eq. BaO in the RO at the expense of the other RO elements, keeping the clay and flint the same (0.05 eq. clay, 0.75 eq. flint). The formula of the glaze used as a base was:

$$(X) \qquad \begin{matrix} 0.28\ K_2O \\ .21\ CaO \\ .21\ ZnO \\ .10\ MgO \\ .20\ BaO \end{matrix} \quad \begin{matrix} 0.33,\ Al_2O_3 \end{matrix} \quad \begin{matrix} 2.53\ SiO_2 \\ .10\ SnO_2 \end{matrix}$$

[1] *Jour. Amer. Ceram. Soc.*, **3**, 13.

The molecular formulas of the various glazes tested for crazing are shown by the series that follows. Maine feldspar was used and the clay was made up of equal parts of Georgia kaolin and Tennessee ball. All glazes contain 0.05 eq. clay and 0.75 eq. flint.

SERIES A—FELDSPAR ADDITION

	1	2	3 = X	4	5
K_2O	0.08	0.18	0.28	0.38	0.48
CaO	.268	.239	.21	.181	.152
ZnO	.268	.239	.21	.181	.152
MgO	.128	.114	.10	.086	.072
BaO	.256	.228	.20	.172	.144
SnO_2	.10	.10	.10	.10	.10
Al_2O_3	.13	.23	.33	.43	.53
SiO_2	1.33	1.93	2.53	3.13	3.73

A1 has a dull mat surface, but is matured. When drawn from the kiln, A1 was badly crazed, A2 and A3 slightly crazed and A4 and A5 sound. On weathering nine months A2, A3, A4 and A5 crazed slightly and there is not a great difference between them.

Additions of Feldspar within the limits of this study does not have a great effect on the crazing. A1 shows the greatest crazing but further additions of feldspar do not show a decided tendency to overcome crazing, although it does act in this way to some extent:

SERIES B—CaO ADDITION

	1	2	3 = X	4	5
K_2O	0.355	0.315	0.28	0.246	0.209
CaO	...	.11	.21	.31	.41
ZnO	.266	.236	.21	.183	.157
MgO	.126	.112	.10	.087	.075
BaO	.252	.244	.20	.174	.15
SnO_2	.10	.10	.10	.10	.10
Al_2O_3	.405	.365	.33	.296	.259
SiO_2	2.98	2.74	2.53	2.33	2.10

B1 is a dull mat, but is matured. When drawn from the kiln B1 was sound, B2 and B3 slightly crazed, B4 shows medium crazing and B5 is badly crazed. On weathering, B1 remained, sound.

Increase of whiting increases crazing with each addition in this study.

SERIES C—ZnO ADDITION

	1	2	3 = X	4	5
K_2O	0.355	0.315	0.28	0.246	0.209
CaO	.266	.236	.21	.183	.157
ZnO	...	.11	.21	.31	.41
MgO	.126	.112	.10	.087	.075
BaO	.252	.224	.20	.174	.150
SnO_2	.10	.10	.10	.10	.16
Al_2O_3	.405	.365	.33	.296	.259
SiO_2	2.98	2.74	2.53	2.33	2.10

When drawn from the kiln, C1 shows medium crazing, C2 and C3 are slightly crazed, and C4 and C5 are sound. On weathering, C1 and C2 showed bad crazing; C3 and C4 are slightly crazed and C5 sound.

Increase of ZnO tends to overcome crazing with each addition.

SERIES D—MgO ADDITION (FROM MAGNESIUM CARBONATE)

	1	2 = X	3	4	5
K_2O	0.311	0.28	0.249	0.218	0.187
CaO	.233	.21	.187	.163	.14
ZnO	.233	.21—	.187	.163	.14
MgO	.0	.10	.20	.30	.40
BaO	.222	.20	.178	.156	.133
SnO_2	.10	.10	.10	.10	.10
Al_2O_3	.361	.33	.299	.268	.237
SiO_2	2.72	2.55	2.34	2.16	1.97

D4 is a dull mat but matured D5 is a trifle immature. When drawn from the kiln, D1 and D2 were slightly crazed, D3 shows medium crazing and D4 and D5 shows bad, fine-mesh, crazing. On weathering, D1 and D2 are slightly crazed and D3, D4 and D5 are badly crazed.

Increase of MgO tends to produce crazing with each addition.

SERIES E—BaO ADDITION AND F—SnO_2 ADDITION

	1	2	3 = X	4	5	F—2	F—3
K_2O	0.35	0.315	0.28	0.245	0.21	0.28	0.28
CaO	.262	.236	.21	.183	.157	.21	.21
ZnO	.125	.112	.10	.087	.075	.10	.10
BaO	.0	.10	.20	.30—	.40	.20	.20
SnO_2	.10	.10	.10	.10	.10	.20	.30
Al_2O_3	.40	.365	.33	.295	.26	.33	.33
SiO_2	2.95	2.74	2.53	2.32	2.11	2.53	2.53

When drawn from kiln, E1, E2 and E3 were slightly crazed. E4 showed medium crazing and E5 was badly crazed. On weathering, crazing increased in all the series and E4 and E5 are badly crazed.

Increase of BaO tends to produce crazing with each addition.

F1 and F2 were slightly crazed, but there is practically no difference between them.

Increase of SnO_2 does not affect the tendency to craze in this study, where the limits of composition were from 0.10 to 0.30 eq.

SERIES G—H—I—J—CLAY AND FLINT VARIATIONS

In these series the Ro is the same as that of the base glaze "X." The clay and flint were varied as follows:

	Eq. Flint				
	1	2	3	4	5
Series G—0.05 eq. clay.....	0.50	0.75	1.00	1.25	1.50
Series H— .10 eq. clay.....	.50	.75	.00	.25	.50
Series I— .15 eq. clay.....	.50	.75	.00	.25	.50
Series J— .20 eq. clay.....	.50	.75	.00	.25	.50

When drawn from the kiln, G1, G2 and G3 were slightly crazed. After weathering six months, no crazing developed in any other glazes in the series of composition shown above. The trials were then re-fired under the same conditions as the original burns to ascertain if any further crazing could be produced by re-firing, but none developed.

Increase of clay decreases crazing with each addition.

The crazing developed on G1, G2 and G3 was very slight and there was practically no difference between them. The fact that the three low flint glazes of the low clay series crazed very slightly, while the two higher flint glazes were sound, shows that what ever influence flint has on crazing is toward overcoming it. Nevertheless, in this study, the effect of flint on the crazing is slight.

Summary

Comparing the effects of equal molecular additions of the various components of the glazes in this study, it was found that ZnO and feldspar overcome crazing, ZnO being the more effective. MgO, BaO and CaO tend to produce crazing, MgO having the

greatest tendency and the effect of BaO being somewhat greater than that of CaO. SnO_2 has no effect on the crazing.

Increase of clay is more effective in overcoming crazing than any other changes that can be made in the glaze formula. Addition of small amounts of clay are more effective in overcoming crazing than much larger additions or substitutions of the other components.

Increase of flint (per molecular equivalent) is less effective in overcoming crazing than increase of either clay, ZnO or feldspar, although, generally, considerable more flint than clay or ZnO can be added without appreciably changing the maturing point of the glaze. In many cases, increase of flint will not overcome crazing in a glaze.

CONKLING-ARMSTRONG TERRA COTTA COMPANY
PHILADELPHIA, PA.

NOTICE—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

Discussion

PROF. C. F. BINNS: I do not find that Mr. Hill gives the composition of the feldspar he uses. He appears to calculate it on the theoretical basis of purity. This does not correspond with my experience. No one of the commercial feldspars shows a potash content of over 14 per cent, and I think that this should be considered in the use of the material.

The conclusion that magnesium, barium and calcium tend to produce crazing in the order given does not accord with my experience in other lines. In the use of magnesium in a glaze my difficulty has been to prevent shivering, and I am of the opinion that the reason why Mr. Hill finds crazing is that the glazes are immature. This, of course, does not effect his result, inasmuch as, under the conditions he shows, magnesia on account of its infusibility may tend to increase crazing.

I suggest this possible cause in order to account for the discrepancy in these conclusions and those usually accepted.

AUTHOR'S CLOSURE: Referring to the criticism of Prof. Binns that feldspar should not be calculated as the theoretically pure material, I would say that this procedure can only be justified as a matter of expediency, as it was desired to standardize the

formulas and results in this study with that of those made previously along the same lines.

In regard to the effect of MgO on this type of glaze, I would say that my experience has been that it does tend to produce crazing. In this study, the effect of the MgO additions was quite marked in this respect. The source of the MgO was "heavy" magnesium carbonate. The same series of glazes were made with steatite as the source of the MgO, with a like result.

All of the glazes containing MgO were well matured with the exception of the one containing 0.40 eq. MgO, the extreme of the series. I cannot agree with the suggestion of Prof. Binns that the glazes containing MgO crazed because they were immature. The immature glazes in this study, with the one exception, were those high in clay, all of which were without crazing.

In this type of glaze, any addition of MgO makes the glaze less fusible. In other types, particularly, those fired at higher temperatures, MgO might become active as a flux and possibly have an effect on crazing just the opposite from that shown in this study. I suggest this as a possible reason why Prof. Binns' experience with regard to the effect of MgO is contrary to mine.

A STUDY OF SPALLING

By Raymond M. Howe and Robert F. Ferguson

Part I.—Definition and Tests for Spalling

When fire-clay brick are subjected to repeated temperature changes, or to unequally distributed or excessive stresses (in arches) pieces become loosened and the fire-brick are said to spall.

The preceding statement is the generally accepted conception of spalling. The "pinching" of arch-brick is due to improper furnace design and this factor is generally disregarded in testing; hence the various tests involve repeated heating and cooling of the specimens. At certain laboratories the fire-brick are placed in the hearth of the furnace and are heated throughout; at others they are placed in the door of the furnace and are heated on one end only.[1] After the specimens have become properly heated they are cooled either by placing in the open air, by partially or totally immersing in water, or by subjecting to a blast of cold air.

It was not deemed advisable, however, to accept any one of these tests as a temporary laboratory standard without conducting a few preliminary trials. Therefore, batches of fire-brick were secured from four manufacturing centers and were subjected to comparative tests.

The general characteristics of these four brands are given in table 1.

Table 1—Physical Properties of Fire-brick T, S, L and D

Brand	Per cent porosity	Total end crushing strength	Fusion point in cones	Per cent compression in 1350° C load test	Permanent linear change after reheating 5 hours at 1400° C
T	24.9	2,220	32	5.1	1.1% contraction
S	17.4	5,846	32–33	4	8 expansion
L	24.9	4,235	29	3.2	0.1 contraction
D	28.2	1,890	30	0.2	1 contraction

[1] Nesbitt and Bell, *Proc. Am. Soc. Testing Materials*, **16**, 369 (1916).

After the necessary preparation, all of the specimens were heated on one end for one hour at 950°C. One-half of these were cooled by immersing to a depth of five inches for three minutes in 1.5 gallons of cold water. They were allowed to air-dry for five minutes and the process was repeated. The other half of the lot was cooled by subjecting the hot end to an air-blast from the 2.5 inch opening of a 1.25 H. P. centrifugal blower.

The results of these tests are given in table 2 and are shown graphically in figures 1 and 2. The loss of weight is taken as the criterion, and it is evident that both methods place the bricks in the same relative order, although the more severe water-cooling method does not give the finer distinction secured by cooling in air.

Since the two procedures placed the four brands in the same relative order, the water-cooling method was considered the better because of its greater rapidity. Consequently, the following test was finally adopted as a temporary standard:

"The dry test specimen is weighed in grams and placed in the door of a furnace operating at 1300–1350°C, care being exercised to prevent the direct heating of more than the 4.5 × 2.5 inch end. After one hour the specimen is stood on end in a tank of flowing cold water so that the hotter portion of the brick (5 inches) is immersed. When pieces become loosened and fall off, the sample is laid on a 4.5 × 9.0 inch asbestos board, subdivided into 100 equal squares, and the approximate percentage of loss estimated."

Later it was found that a certain type of checker brick failed after about three immersions in water and that it was necessary to use the air blast in comparing[1] fire-brick of this type.

Part II.—Comparison of Laboratory Tests and Behavior in Service

The previously described test was used in this laboratory for nearly two years, and in every case gave results which were in harmony with the results of experience. During this period of time, however, it received a rather narrow application, for only samples which were made at the same plant were compared at any one time.

[1] A paper on this subject will appear in the near future.

FIGURE ONE

BEHAVIOR OF FOUR BRANDS IN AIR-COOLING SPALLING TEST

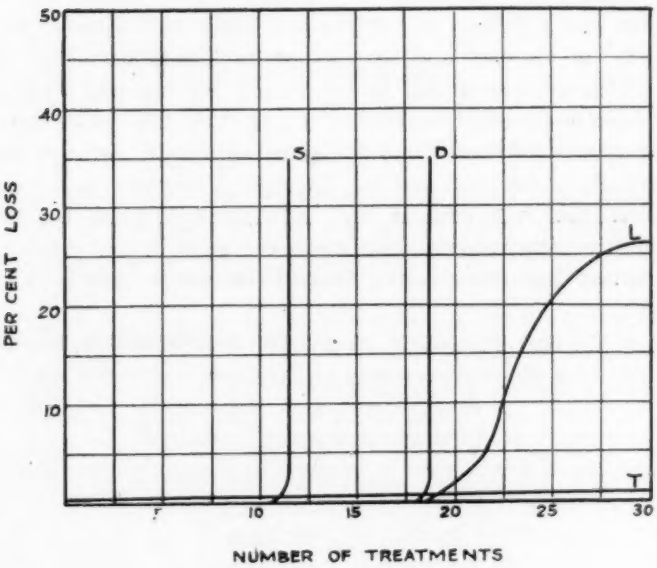


FIGURE TWO

BEHAVIOR OF FOUR BRANDS IN WATER-COOLED SPALLING TEST

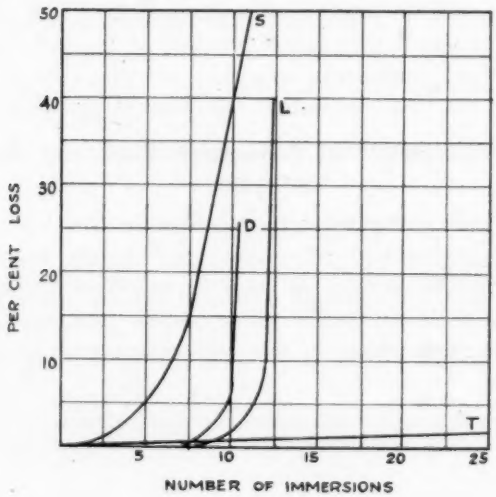


TABLE 2—SPALLING LOSSES OF DIFFERENT FIRE-BRICK WHEN COOLED BY AIR AND WATER

Number of times cooled	Per cent loss							
	T		S		L		D	
	Air	Water	Air	Water	Air	Water	Air	Water
1	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1
2	.1	.1	.1	.0	.1	.1	.1	.1
3	.1	.1	.1	.0	.1	.1	.1	.1
4	.1	.1	.1	.0	.1	.1	.1	.1
5	.1	.1	.1	4.4	.1	.1	.1	.1
6	.1	.2	.1	.4	.1	.2	.1	.3
7	.1	.2	.1	9.6	.1	.2	.1	.3
8	.1	.2	.1	.6	.1	.2	.1	.3
9	.1	.2	.1	.6	.1	.9	.1	.3
10	.1	.3	.1	.6	.1	.9	.1	19.5
11	.2	.3	.1	.8	.1	.9	.1	..
12	.2	.3	.1	50+	.1	.9	.1	..
13	.2	.6	.1	..	.1	8.2	.2	..
14	.2	.6	34.0	..	.1	40.0	.2	..
15	.2	.6	..	..	.1	..	.2	..
16	.2	.6	..	..	.1	..	0.2	..
17	.2	.7	..	..	.1	..	.2	..
18	.2	1.0	..	..	.1	..	34.0	..
19	.2	.0	..	..	.1	..	..	..
20	.2	.0	..	..	.1	..	..	..
21	.2	.2	..	..	.1	..	..	..
22	.2	.2	..	..	.1	..	..	..
23	.3	.2	..	..	.1	..	..	..
24	.3	.2	..	..	.2	..	..	..
25	.3	.2	..	..	16.5	..	..	..
26	.3	.7	..	..	.5	..	..	..
27	.3	.7	..	..	.5	..	..	..
28	.3	.7	..	..	.5	..	..	..
29	.3	.8	..	..	.5	..	..	..
30	.3	.8	..	..	.5	..	..	..
31	.3	.8	..	..	23.3	..	..	..
32	.3	.8	..	..	.3	..	..	..
33	.3	.8	..	..	.3	..	..	..
34	.3	.8	..	..	.3	..	..	..
35	.3	.8	..	..	.3	..	..	..
36	.3	2.2	..	..	.3	..	..	..
37	..	.2	..	..	..	..	..	..
38	..	.2	..	..	..	..	..	..
39	..	.2	..	..	..	..	..	..
40	..	.8	..	..	..	..	..	..

FIGURE THREE
RELATIVE RESISTANCE TO SPALLING OF SEVERAL FIREBRICKS MADE AT THE SAME PLANT BUT BY DIFFERENT PROCESSES

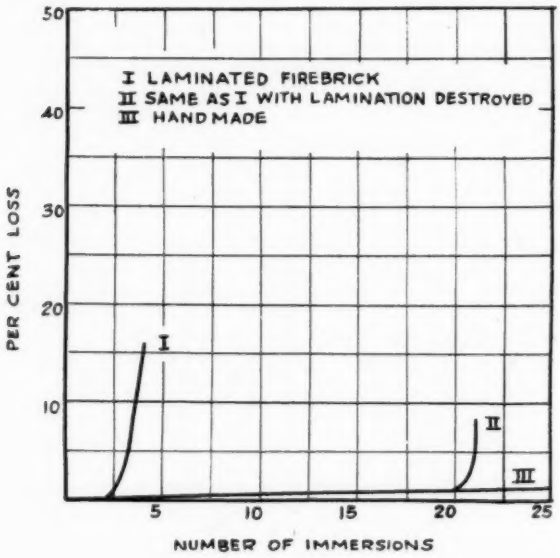
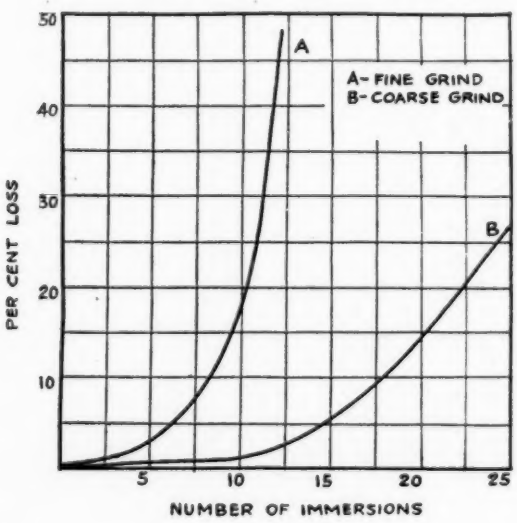


FIGURE FOUR
RELATIVE RESISTANCE TO SPALLING OF COARSE AND FINE GRAINED FIREBRICK OF SIMILAR COMPOSITION



In one instance three processes of manufacture were applied to a certain batch of clays. The resulting product was therefore of practically the same grind and burn, but differed considerably in structure. The results of the tests are given in figure 3, and show the decided structural differences of the different products.

In a second case the clays were ground to different sizes, but the samples were otherwise identical. The spalling test results secured from these specimens are given in figure 4. The advantage possessed by the coarser ground mixture, with respect to resistance to spalling, is evident.

A third citation refers to fire-brick which were made as nearly alike as possible except for hard and soft burning. The comparisons are shown by figure 4 and bring out the superiority of light burned products, from this standpoint, very strikingly.

The results shown in figures 3, 4, and 5 were considered favorable, because in each case they conform to what has been observed. In the following citation fire-brick of widely different characteristics were under consideration, and here the test results showed a decided lack of agreement with what is known to obtain in service. Fire-brick A is usually considered as a "non-spalling" roof brick; C spalls were A does not; B assumes an intermediate position. Other characteristics of these three brands are given in table 3.

TABLE 3—GENERAL CHARACTERISTICS OF FIRE-BRICKS A, B AND C

Ultimate Chemical Analysis	A	B	C
Per cent of silica	81.02	55.04	52.95
Per cent of alumina	16.58	39.91	42.95
Per cent of ferric oxide	1.46	3.65	2.32
Per cent of lime	0.40	0.48	0.10
Per cent of magnesia	.16	.28	.31
Per cent of soda	.32	.40	.67
Per cent of potash	.38	.39	.66
Total	100.32	100.15	100.20
Fusion point in cones	29	32–33	33
Compression in 1350° C load test	1.2%	4.8%	5.2%
Porosity of "run of kiln" brick	30.45	21.09	21.00
Porosity after reheating to 1400° C.	32.08	18.43	17.70
Porosity change during reheating	+1.63	− 2.66	− 2.30
Linear change after reheating five hours at 1400° C	0.00	0.15% Exp.	0.61% Exp.

FIGURE FIVE
RELATIVE RESISTANCE TO SPALLING OF HARD AND SOFT BURNED BRICK

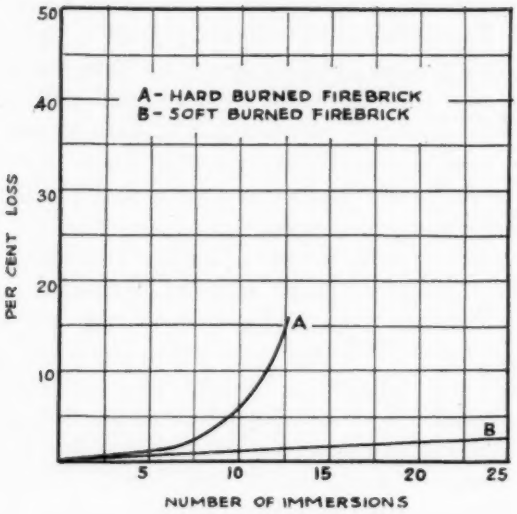
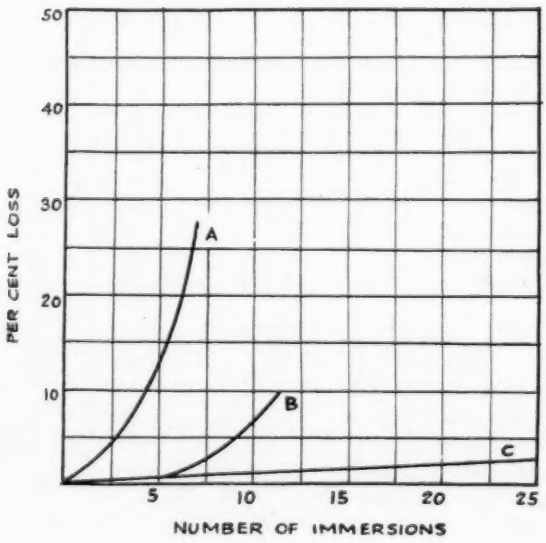


FIGURE SIX
SPALLING TESTS ON "RUN OF KILN" BRICKS "A," "B," AND "C."



The results of the spalling tests made upon these three brands are given in table 4 and are shown in figure 6.

TABLE 4—SPALLING LOSSES OF RUN OF KILN FIRE-BRICK WHEN DIPPED IN WATER

Number of dips	Per cent loss		
	A	B	C
2	0.0	0.0	0.0
4	8.0	.0	.0
6	28.0	.7	.0
8	..	2.3	.0
10	..	4.7	.2
12	..	10.7	.5

In view of the facts developing by the preceding examples, the conclusion was drawn that the usual spalling test gives accurate information when the specimens are made from the same fire-clays, but when fire-clays from different districts are compared the results are not in accordance with their behavior in service.

Part III.—Further Development of the Spalling Test

There are two distinct types of fire-clay which, when used in the manufacture of fire-brick, give a product particularly resistant to spalling. The temperature porosity curves for two fire-clays of this nature are given in figure 7, and show that these clays are characterized by a constancy in porosity for a wide range of temperature.

Since clays of this kind undergo only a slight change in porosity when heated, they are considered as being very resistant to vitrification, for decrease in porosity is the best criterion of vitrification.[1]

It is also known that when fire-brick spall in service the pieces are usually dense or vitrified. Consequently, the possibility of a relation between vitrification and spalling was suggested. In order to develop this relation, specimens of fire-brick C were prepared by heating for five hours at 1200°, 1300°, 1400°, and 1450° C. This series therefore represented various stages of vitrification, depending upon the highest temperature to which the different samples had been heated.

[1] Brown and Murray, *Trans. Am. Ceram. Soc.*, **15**, 173 (1913); Edward Orton, Jr., *Ibid.*, **16**, 497 (1914).

FIGURE SEVEN

A- OPEN BURNING FLINT CLAY
B- HIGH GRADE OPEN BURNING PLASTIC CLAY

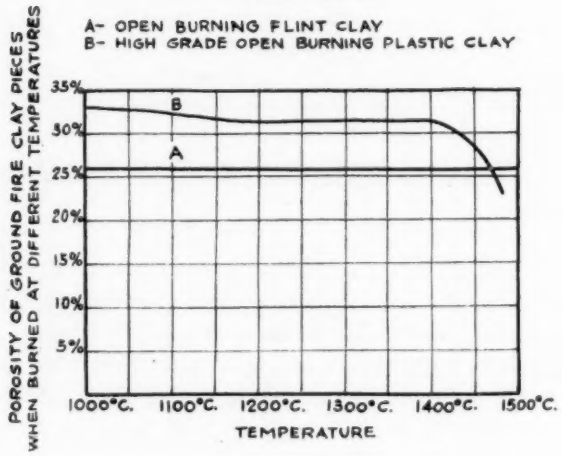
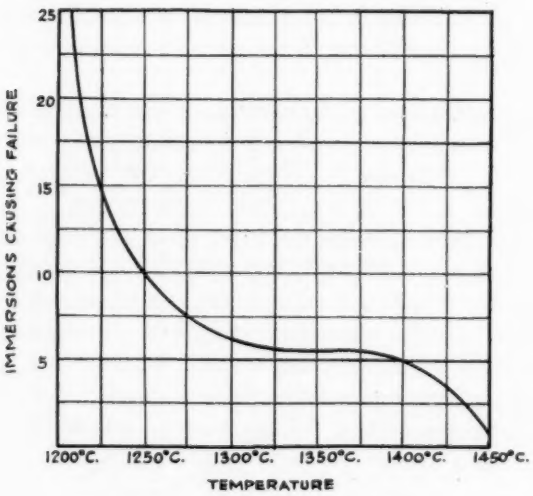


FIGURE EIGHT
RELATION BETWEEN SPALLING TENDENCY AND TEMPERATURE



The reheated samples were then subjected to the usual spalling test, with water as the cooling medium. When each specimen lost over 33 per cent the number of immersions necessary to produce this failure was recorded as its spalling value. These data were collected and plotted in figure 8, which shows very clearly that resistance to temperature change is a function of vitrification. It is a well-known fact that hard burned (or more completely vitrified) products have a higher coefficient of expansion than those which are soft burned. It has been demonstrated that the harder burned products are also less resistant to spalling. Consequently, it may be that the spalling of fire-clay brick is also associated with thermal expansion, as is the case with silica brick. In the case of fire-brick, however, the thermal expansion will vary with the hardness of burn or completeness of vitrification, and so resistance to temperature change should be considered a function of vitrification.

Vitrification *per se*, however, is not a constant factor, and both the rate and magnitude of the porosity change must be considered. Again, in some cases it may be the result of a predominatingly chemical action, while in others the action is largely physical,[1] and it is probable that no two clays vitrify at the same rate or in the same manner.[2] Therefore, it is reasonable to expect a change in the relative vitrification of almost any two fire-bricks when heated from 1100°C. to 1400°C. With this thought in mind several samples of A, B and C were heated for five hours at 1400°C. The porosity of C decreased 2.6 per cent, that of B decreased 2.2 per cent, and that of A remained practically constant. C became very dense during reheating, B underwent considerable change, but A showed no visible signs of vitrification.

These reheated specimens were then tested for spalling; one-half of them were air-cooled and the other half were water-cooled. The spalling test results obtained in this manner are given in tables 5 and 6 and in figures 9 and 10.

[1] Brown and Murray, *Trans. Am. Ceram. Soc.*, **15**, 193 (1913).

[2] See curves. Bleininger and Loomis, *Ibid.*, **19**, 601 (1917).

FIGURE NINE
SPALLING TESTS ON BRICKS "A," "B," AND "C" AFTER REHEATING 5 HOURS AT 1400°C. AND DIPPING

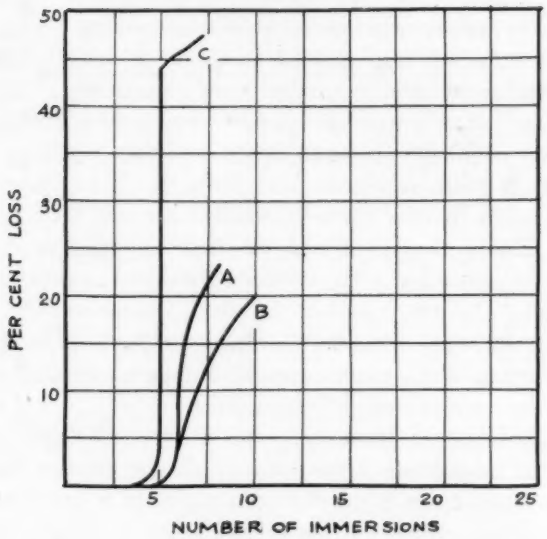


FIGURE TEN
SPALLING TESTS ON FIREBRICK "A," "B," AND "C" AFTER REHEATING FIVE HOURS AT 1400°C. AND SUBJECTING TO THE AIR-BLAST

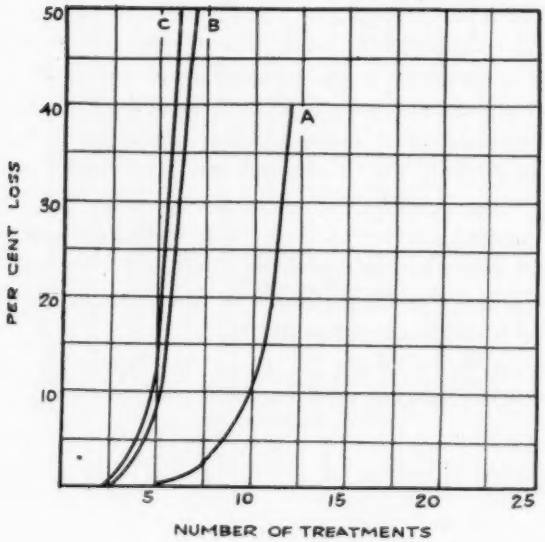


TABLE 5—AVERAGE PER CENT SPALLING LOSSES OF REHEATED SPECIMENS OF A, B AND C, WHEN COOLED IN WATER

Number of immersion	A	B	C
2	0.0	0.0	0.0
4	.0	.3	.0
6	.3	5.3	44.5
8	23.6	7.0	..
10	..	20.3	..

TABLE 6—AVERAGE PER CENT SPALLING LOSSES OF REHEATED SPECIMENS OF A, B AND C WHEN COOLED IN AIR

Number of treatments	A	B	C
2	0.0	0.0	0.0
4	.0	3.2	6.0
6	.0	19.8	50.0±
8	3.0	Broke after 7	..
10	5.0	..	..
12	39.8	..	..

When the various spalling test results are compared it is obvious that those secured from reheated fire-brick are in close agreement with service data. The position of C is changed entirely and A is given a more correct rating. For some unknown reason B did not give the expected results when reheated and water-spalled; when reheated and air-spalled it assumed the expected position. However, this slight discrepancy is overshadowed by the behaviors of A and C.

It should be noted that A, which is made from open burning fire-clay, underwent but very little change in resistance to spalling when reheated. C, which became very dense in reheating, suffered a radical decrease in resistance to spalling. Another point of interest concerns the fact that the air-cooling method, when applied to reheated fire-brick, gives sufficiently rapid results to justify its adoption.

In summarizing Part III it may be said that a relation has been shown between porosity, vitrification and spalling, for as vitrification increases, resistance to spalling decreases. Since vitrification is associated with porosity decrease it is believed that the following statement is justified:

"Fire-clays which undergo a slight change in porosity when heated over a wide range of temperature have a very slight

tendency to vitrify and are therefore particularly adapted to the manufacture of non-spalling fire-brick."

In view of the preceding results it is also evident that a broader interpretation should be given to spalling and the following statement may possibly meet this requirement:

When portions of fire-brick become loosened in service under the influence of fluctuations in temperature they are said to spall; density due to vitrification, improper brick structure, and unequally distributed stresses facilitate this action.

Part IV.—Application of Porosity-Spalling Theory

Within the past year certain hand-made special shapes, made of two clays used in equal proportions, were found to spall badly in service. When specimens were water spalled, however, they lost less than 3 per cent after twenty immersions. This test proved that the structure of the shapes was satisfactory, and suggested that the clays were at fault. Therefore porosity-temperature determinations were made for clays X and Y and these are given in figure 11. When these curves were examined it was obvious that the dense burning clay Y was more likely to be the cause of spalling than the open burning clay X. The composition of the batch was therefore changed so as to include only 20 per cent of Y, whereas the original batch contained 50 per cent of each clay. The theoretical porosity curve of the original batch is shown as Z and ZZ is the corresponding curve for the revised batch.

The manufactures of these shapes have stated that spalling ceased when the composition of the batch was changed as above suggested. Thus, this case substantiated the porosity-spalling theory, and proved that spalling is not always due to improper fire-brick structure but is largely controlled by the thermal properties of the raw clays.

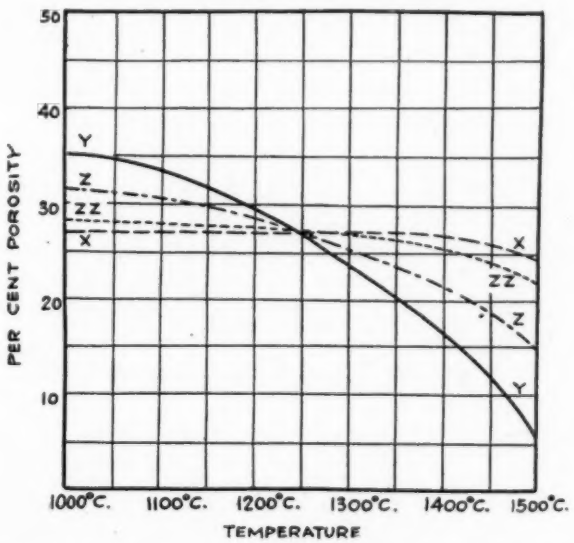
Undoubtedly this same procedure can be applied to the development of bung brick, glass pot mixes, and any other products that may spall.

Part V.—Application of Results to Testing

In Part II it was conclusively proved that the usual spalling tests give reliable information when applied to fire-brick made from the same clays. It was also shown that tests of this nature

fail when applied to fire-brick coming from different localities. This condition is undoubtedly due to the fact that fire-brick structure is overemphasized by the usual spalling test, while the characteristics of the raw clays are not revealed. The results given in Part IV are ample proof for this statement. Consequently, the development of a satisfactory spalling test is a relatively simple matter for any one manufacturer, but when a consumer buys his product from different sources the problem is more intricate.

FIGURE ELEVEN
POROSITY TEMPERATURE CURVE FOR
CLAYS USED IN SPECIAL SHAPES



However, it is believed that the present investigation has revealed certain factors which can not be neglected in the development of a spalling test. It is essential that the fire-brick be given a severe heat treatment before they are air- or water-spalled. The severity of this treatment should depend upon the service in which the various samples are to be placed.

The objection has been raised that roof brick are heated on one surface only, while in the revised test they are heated throughout. This objection is not considered serious, however, because

of the fact that roof brick which will not vitrify in service will not vitrify in reheating, whereas fire-brick which tend to vitrify will do so both in service and in reheating.

Naturally, a dense burning fire-brick will spall more quickly either in service or in testing, if this characteristic is revealed; with an open burning fire-brick spalling in service is less noticeable and it has been shown that the resistance of specimens of this type to the spalling test is not decreased by reheating (see results secured with A). In other words, the practice of reheating is justified, or condemned, by the presence of, or lack of, a relation between vitrification and spalling. It is believed that this relation has already been establised.

A second objection to reheating the spalling test samples lies in the fact that many roof brick are purposely burned "soft" in order to secure the maximum resistance to spalling from a given set of clays. Reheating fire-brick of this type would undo a part of the work of the manufacturer, although treating different specimens in exactly the same manner might still leave them in the same relative order.

So far as can be determined at present there is no possible objection to reheating checker brick (at a temperature equivalent to the working temperature) before subjecting them to the air or water-spalling test.

It is believed that the preceding results warrant the following conclusions.

1. Air-cooling and water-cooling spalling tests give similar results.

2. These results lead to accurate conclusions where the same fire-clays are involved, but misrepresent the facts when different clays are concerned.

3. These discrepancies may be overcome by reheating the test specimen before subjecting it to the spalling test.

4. The necessity for reheating arises from the great differences in the vitrification behavior of different fire-clays.

5. Vitrification is closely associated with spalling.

Refractories Manufacturers Association Multiple Fellowship No. 4
Mellon Institute of Industrial Research
Pittsburgh, Pa.

February 25, 1920

A READING LIST ON VITREOUS ENAMELING ON IRON AND STEEL[1]

By Clarence Jay West

The literature of the ceramic industry is very well covered up to the year 1906 by the Bibliography of Clays and the Ceramic Arts compiled by John C. Branner. The following reading list, therefore, begins with the year 1907. The articles listed deal more with the chemical principles involved than with mechanical methods. References are given to the abstracts printed in Chemical Abstracts or in the Journal of the Society of Chemical Industry. These abstracts are reproduced in part below, though where the abstract is long, or where the title indicates the scope of the article, abstracts are usually omitted. Reference to abstracts will enable the investigator to eliminate many articles as being unsuitable for his particular purpose. United States patents on enameling are omitted, as they have been in This Journal, vol. 3 page 893 to 900. Directions for ordering foreign patents may be found in Chemical Abstracts, vol. 13, no. 6 (March 20, 1919).

Books

Bollenbach, H. Keramische Rechentaflen zum Gebrauch in den Laboratorien der Ton-, Glas-, und Email Industrie. Halle: W. Knapp. 105 pages.

Brown, W. N. Art of enameling on metal. 2nd Edition. 1914. London: Scott, Greenwood and Son. 58 pages.

Chapin, H. M. How to enamel. 1911. Wiley.

Day, L. F. Enameling. 1908. Scribner.

Emailleindustrie. Dresden. IV, 255 pages.

Eyer, Ph. Anlagen und Einrichtungen e. Emailliewerke. Berlin: Keram. Rundschau. 44 pages.

Eyer, Ph. Emaille-Wissenschaft: In gemeinverstandl Auslegung. Dresden: Verlag "Die Glasshütte." 224 pages.

Fisher, A. Art of enameling upon metals. 1906. Lane. 38 pages, 26 plates.

[1] Received Oct. 5, 1920.

Franchet, L. La fabrication industrielle des emaux et couleurs ceramiques. 1911.

Grampp, O. Practical enameler. 1909. William.

Griffin, H. R. Clay glazes and enamels, with a supplement on crazing, its causes and prevention, 1913. Randall and Co.

Grünwald, J. La technique de l'emaillerie moderne. Paris: H. Dunod et Pinat.

Grünwald, J. The raw materials for the enamel industry and their technical technology. Translated from the German by H. H. Hodgson. 1914. London: C. Griffin and Co. viii, 225 pages.

Grünwald, J. The technology of iron enameling and tinning. 1912. London: C. Griffin and Co. 138 pages.

Grünwald, J. The theory and practice of enameling on iron and steel with historical notes on the use of enamels. Translated by H. H. Hodgson. 1910. London: C. Griffin and Co. vii, 131 pages.

Havas, B. Uber Eisenblechemaille. 1910. (Dissertation of the Tech. Hochschule zu Karlsruhe.)

Landrum, R. D. Enamels. 1918. Cleveland: Harshaw Fuller and Goodwin Co. 106 pages.

Millenet, L. Manuel pratique de l'emaillage sur metaux. 1917.

Maryon, H. Metal work and enameling. 1913. London: Chapman and Hall. 342 pages.

Shaw, J. B. Enamels for sheet iron and steel. 1920. Washington: United States Bureau of Standards. Technologic Paper 165. 88 pages..

Staley, Homer F. Materials and methods used in the manufacture of enameled cast-iron wares. 1919. Washington: United States Bureau of Standards. Technologic Paper 142. 158 pages.

Turner, William. Transfer printing on enamels, porcelain and pottery.

Articles in Periodicals

1907

Chem. Fabrik Güstrow, Hillringshaus, and Heilmann. Manufacture of a white translucent enamel. German Patent 207,001. Aug. 6, 1907. *C. A.*, **3**, 2044. A small amount of cobalt oxide is added to the enamel material containing titanic acid with the view of covering the yellowish tint of the titanic flux.

Chem. Fabrik Güstrow. White clouded enamels English Patent 12,583, May 30, 1907. *C. A.*, **3**, 587; *J. Soc. Chem. Ind.*, **27**, 810. Artificially produced titanates of alkaline earth or earth metals are used.

Klissner, J. Kiln for enameled articles, in which these do not come in contact with the flame. German Patent 203,296. Apr. 10, 1907. *J. Soc. Chem. Ind.*, **27**, 1204.

Rickmann and Rappe. Manufacture of an opaque enamel. German Patent 203,773, June 30, 1907. *C. A.*, **3**, 699; *J. Soc. Chem. Ind.*, **28**, 92. Cerium carbonate is ground with the previously melted enamel and burned on the metal plate.

Riddle, F. H. The type of enamel used for enameling cast iron sanitary ware. *Trans. Amer. Ceram. Soc.*, **9,** 645–61 (1907); *C. A.*, **2,** 1483; *J. Soc. Chem. Ind.*, **27,** 565. The most favorable composition was found to be: 0.4 PbO and BaO, 0.15 K_2O, 0.15 CaO, 0.05 ZnO, 0.25 Na_2O, 0.15 Al_2O_3, 1.0 SiO_2, 0.2 B_2O_3, 0.2 SnO_2.

Spitz, G. Process of detaching enamel from enameled objects. French Patent 370,986, Oct. 31, 1906. English Patent 5,273, Mar. 5, 1907. *C. A.*, **2,** 204; *J. Soc. Chem. Ind.*, **26,** 257. A solution of caustic soda or oxalic acid at 100° C. is used, either with or without a quantity of oxidizing medium.

1908

Act.-Ges. der Emailliewerke und Metallwaarenfabriken "Austria." Process for producing a metallic luster on enameled metallic surfaces. French Patent 388,761, Apr. 1, 1908. *J. Soc. Chem. Ind.*, **27,** 982.

Bock, B. Importance of fluorine in enamels. *Chem.-Ztg.*, **32,** 730–2 (1908); *C. A.*, **2,** 2718; *J. Soc. Chem. Ind.*, **27,** 900. Fluorine lowers the melting point of the enamels decidedly but has no influence on the opacity of the resulting enamel.

Bock, B. Note on white antimony enamels. *Chem.-Ztg.*, **32,** 446–7 (1908); *C. A.*, **2,** 2132; *J. Soc. Chem. Ind.*, **27,** 566. Dangers are pointed out, owing to the ready solubility and the poisonous character of the compounds of antimony. Slow cooling of frits in place of the rapid quenching is advised.

Bonzel, C. and P. Continuous furnace for burning enameled ware out of contact with flames. French Patent 392,285, July 13, 1908. *J. Soc. Chem. Ind.*, **27,** 1204.

Enameling of sheet iron hollow ware. *Keram. Rundschau*, **16,** 89–91, 135–9 (1908); *C. A.*, **2,** 1605. Various formulas are given in which zirconium is replacing tin.

Eyer, P. Advances in the preparation of enamel glazes (for iron). *Chem.-Ztg.*, **32,** 516–7 (1908); *J. Soc. Chem. Ind.*, **27,** 628.

Eyer, P. Tin oxide substitute. *Stahl u. Eisen*, **28,** 1097–9 (1908); *C. A.*, **2,** 3135. Tests of cryolite, which may replace about 12 per cent of tin, antimony, and arsenic oxides, bone ash, titanic acid and zirconium oxide.

Franchet, Louis. The enamels and ceramic colors of the Middle Ages and the Renaissance. *La Ceramique*, **10,** 142; *C. A.*, **2,** 2609. Various compositions are given.

Home office regulations for vitreous enameling metal or glass. Statutory Rules and Orders, 1908, No. 1258, Dec. 18, 1908. *J. Soc. Chem. Ind.*, **28,** 91.

Landau et Cie., and Rosenzweig, C. White enamel of great covering power. French Patent 389,483, Apr. 22, 1908. *C. A.*, **4,** 2720; *J. Soc. Chem. Ind.*, **27,** 983; *La Ceramique*, **11,** 100–1; *C. A.*, **3,** 364. Silicates of zirconium and beryllium are used in place of tin, etc. They are more refractory, more resistant to acids and are cheaper.

Recovery and utilization of enamel wastes. *Rev. chim. ind.*, **19,** 160; *C. A.*, **2,** 2718.

Staley, H. F. The compounding of frits. *Trans. Amer. Ceram. Soc.*, **10,** 113–23 (1908); *C. A.*, **2,** 3392.

Vollkommer, Joseph. Furnaces for the enameling industry. *Iron Age*, **82,** 648–9 (1908); *C. A.*, **2,** 2981.

Vondracek, R. Enameling of iron. *Sprechsaal*, **41,** 475–7, 493–5, 507–8 (1908); *J. Soc. Chem. Ind.*, **27,** 1020.

Woog, P., and Delage, M. Process of enameling in one stage. French Patent 401,543, July 29, 1908. *J. Soc. Chem. Ind.*, **28,** 1130. An acetylene flame is directed onto the spot where the enamel is required and the finely ground enamel is also projected on the same spot.

1909

Bock, B. Fixation materials in enamel making. *Chem.-Ztg.*, **33,** 109 (1909); *C. A.*, **3,** 1450. Fixation materials are those substances which have the effect of holding the fine enamel glass particles in suspension, thus preventing their settling to the bottom of the mass after fusion. These include clay; insoluble magnesium salts; soluble, neutral salts, such as ammonium chloride (volatile), alkali carbonates and sulfates (partly volatile), and borax (non-volatile).

Colin, G., et Cie. Process of enameling cast iron articles and especially pots and cooking utensils. French Patent 411,630, Apr. 14, 1909. *J. Soc. Chem. Ind.*, **29,** 951. The interior of the pots is polished and then oxidized into a layer of magnetic oxide of iron, to which the enamel is applied by the wet process and as liquid as possible.

Enequist, Erik. The chemistry of opaque glass and enamel. *Chem. Eng.*, **10,** 54; *C. A.*, **3,** 2865.

Fletcher, D. Enameling muffles. English Patent 25,692, Nov. 8, 1909. *J. Soc. Chem. Ind.*, **29,** 1383.

Frink, R. L. The chemistry of opaque glass and enamel. *Chem. Eng.*, **10,** 128–9 (1909). A criticism of the work of Enequist

Grünwald, Julius. Annealing and pickling of the finished iron articles before enameling. *Stahl u. Eisen*, **29,** 137–40 (1909); *C. A.*, **3,** 878; *J. Soc. Chem. Ind.*, **28,** 204.

Grünwald, Julius. Cast iron enamels. *Stahl u. Eisen*, **1909,** 137; *Sprechsaal*, **43,** 485–7 (1910); *C. A.*, **5,** 168.

Grünwald, Julius. Enameling and the function of clay in the enamel. *Sprechsaal*, **42,** 287–9 (1909); *C. A.*, **3,** 1674; *J. Soc. Chem. Ind.*, **28,** 600. A general discussion.

Grünwald, Julius. Note on the technology of the enameling industry. *Oesterr. Chem. Ztg.*, **11,** 271; *C. A.*, **3,** 2364. The density of certain enamels is given, with and without water. Certain analytical methods are also given.

Hartmann, A. Zircon enamel. *Z. anorg. Chem.*, **1909,** 178–227; *Keram. Rundschau*, **19,** 118–28 (1911); *C. A.*, **5,** 1981.

Lesmuller, A. Process for making glass and enamels opaque. German Patent 218,316, April 1, 1909. *J. Soc. Chem. Ind.*, **29,** 420. Oxides of tin, silicon, lead, titanium, zirconium or thallium are fused with boric acid derivatives and the fused mass exposed to the action of steam or acid vapors while it cools and the solid product subsequently melted with the enamel.

Mayer, M., and Havas, B. Expansion coefficient of sheet iron enamels. *Chem.-Ztg.*, **33,** 1314; *C. A.*, **4,** 1092.

Mayer, M., and Havas, B. The coefficient of thermal expansion of sheet iron enamels. *Sprechsaal*, **42,** 497–9 (1909); *C. A.*, **3,** 2494; *J. Soc. Chem. Ind.*, **28,** 1199. Six different enamels were studied.

Mayer, M., and Havas, B. The function of fluorine compounds in enamels. *Sprechsaal*, **42,** 460–1 (1909); *Chem.-Ztg.*, **33,** 758 (1909); *C. A.*, **3,** 2740, 3001; *J. Soc. Chem. Ind.*, **28,** 835. Fluorine is a good opacifier and permits the tin oxide to be decreased to 3 per cent and still maintain excellent covering power.

Orton, Edward, Jr. Notes on the testing of enameled sheet steel wares. *Trans. Amer. Ceram. Soc.*, **11,** 320–41 (1909); *C. A.*, **3,** 2741; *J. Soc. Chem. Ind.*, **28,** 1130.

Shaw, Joseph B. The allowable limit of variation in the ingredients of enamels for sheet steel. *Trans. Amer. Ceram. Soc.*, **11,** 103–52 (1909); *C. A.*, **3,** 2740; *J. Soc. Chem. Ind.*, **28,** 1130. A discussion of the manufacture of sheet steel enameled ware, followed by an investigation of fitting ground and top coats to a particular Bessemer steel. It is replete with details and explanations.

1910

de Back, A. Method and apparatus for recovering iron and steel from waste enameled articles. English Patent 3375, Feb. 11, 1910. *J. Soc. Chem. Ind.*, **29,** 1390. The articles are first pressed together to crack the enamel and the enamel then scraped off.

Cavanaugh, J. A. Large electric enameling oven. *Elec. World*, **56,** 685–6; *C. A.*, **5,** 29.

Cheney, Merritt B. The limits of composition of enamels for cast iron. *Trans. Amer. Ceram. Soc.*, **12,** 543–7 (1910); *C. A.*, **5,** 362.

Goldschmidt, Th. Removing enamel and recovering the iron. German Patent 242,055, April 2, 1910. French Patent 418,971, Aug. 1, 1910. *C. A.*, **6,** 2157; *J. Soc. Chem. Ind.*, **30,** 92.

Grünwald, J. Cast iron enamels. *Stahl u. Eisen*, **30,** 1201–6 (1910); *J. Soc. Chem. Ind.*, **29,** 951.

Grünwald, J. The stiffening of wet ground enamels. *Sprechsaal*, **43,** 594–7 (1910); *C. A.*, **5,** 168; *J. Soc. Chem. Ind.*, **29,** 1251. The reagents recommended are ammonium chloride or carbonate, magnesium oxide and borax.

Hillringhaus and Heilemann. Zirconium oxide as a clouding agent in enamels and glasses. *Z. anorg. Chem.*, **66,** 436; *C. A.*, **5,** 167.

Holcroft, Harold. The principles of vitreous enameling of cast iron for industrial purposes. *J. Soc. Chem. Ind.*, **29**, 121–5 (1910); *C. A.*, **4**, 1227. Four methods are discussed.

Landau et Cie, and Rosenzweig. White enamel. French Patent 417,078, June 13, 1910. *J. Soc. Chem. Ind.*, **29**, 1383. A substitute for tin oxide is prepared by heating zirconium and calcium nitrates in the proportions necessary to give 70 per cent zirconium and 30 per cent calcium.

Landau, Kreidl, Heller and Co. White enamels. German Patent 274,860, June 11, 1910. *C. A.*, **8**, 3107. Discusses the use of zirconium compounds.

Landrum, R. D. The manufacture of enameled ware. *Trans. Kansas Acad. Sci.*, **22**, 76–80; *C. A.*, **4**, 1532. A brief but interesting description.

Landrum, Robert D. Methods of analysis for enamels and enamel raw materials. *Trans. Amer. Ceram. Soc.*, **12**, 144–74 (1910); *Glasind.*, **26**, **27**, **28**; *C. A.*, **4**, 258; *J. Soc. Chem. Ind.*, **29**, 1310.

Mayer, M., and Havas, B. The function of the ground enamel. *Sprechsaal*, **43**, 727–9 (1910); *C. A.*, **5**, 1981.

Muffle kilns for iron enameling and other industrial purposes. *Stahl u. Eisen*, **1910**, No. 36; *Keram. Rundschau*, **18**, 495–7, 507–9, 520–3 (1910); *C. A.*, **5**, 580.

Shaw, J. B. Testing sheet steel enamels. *Trans. Amer. Ceram. Soc.*, **12**, 463–93 (1910); *C. A.*, **5**, 168; *J. Soc. Chem. Ind.*, **29**, 1310.

Sonntag, S., and A. Enameled metal ware. German Patent 239,252, Aug. 13, 1910. French Patent 419, 433, Aug. 17, 1910. English Patent 19,233, Aug. 16, 1910. *C. A.*, **6**, 2155; *J. Soc. Chem. Ind.*, **29**, 1383. The cleaned surface is wetted with water to which a glutinous substance has been added and the enamel powder sifted on.

Tafner, H. Fluorite and its function in enamels. *Sprechsaal*, **43**, 36–7 (1910); *C. A.*, **5**, 773; *J. Soc. Chem. Ind.*, **29**, 213. Enamels containing calcium fluoride do not represent stable compounds as fluorine continues to be given off on heating.

Underhill, D. Enameled cast iron sanitary ware. *Foundry*, **36**, 17; *C. A.*, **4**, 2668. A good general survey of the entire field.

Weiss, Ludwig. Zirconium oxide as a clouding agent in enamels and glasses. *Z. anorg. Chem.*, **67**, 456; *C. A.*, **5**, 168.

1911

Coethen. The training of engineers for enamel works at Friedrich-Polytechnicum. *Glashütte*, **41**, 309–10; *C. A.*, **5**, 2711.

Colin, L. V. Enameling. English Patent 17,270, July 28, 1911. *C. A.*, **7**, 407.

Cox, John H. Comparison of commercial ground coats for cast iron enamels. *Trans. Amer. Ceram. Soc.*, **13**, 531–49 (1911); *C. A.*, **5**, 3892; *J. Soc. Chem. Ind.*, **30**, 1386.

Deutsche Stahhottich Ges. Subsequent enameling of rough places and weld-

ing of enameled articles. German Patent 251,059, Sept. 5, 1911. *C. A.*, **7**, 235.

Eyer, Ph. How much of the heat applied to enamel firing and melting ovens is useful? *Glashütte*, **41**, 931–2; *C. A.*, **6**, 415.

Franchet, L. Preparation of Grecian black enamel with natural ferroso ferric oxide. *Compt. rend.*, **152**, 1097–1100 (1911); *J. Soc. Chem. Ind.*, **30**, 622.

Green enamels for galvanized iron. *Glashütte*, **41**, 604–6, 649–51 (1911); *C. A.*, **5**, 3503.

Grünwald, J. The chemical technology of enamel raw material. *Glashütte*, **40, 41, 42**. In 42 installments. See under Books, also.

Grünwald, J. The use of zirconia in the enameled iron industry. *Sprechsaal*, **44**, 72–3 (1911); *C. A.*, **5**, 2163; *J. Soc. Chem. Ind.*, **30**, 210. Doubt is expressed as regards the efficiency of zirconium oxide as an opacifier.

Havas, B. The function of the ground enamel. *Sprechsaal*, **44**, 72–3 (1911); *C. A.*, **5**, 2163.

Landau et Cie, and Rosenzweig, C. White enamels. English Patent 10,418, Apr. 29, 1911. French Patent 429,665, May 12, 1911. *C. A.*, **6**, 2986; *J. Soc. Chem. Ind.*, **30**, 1213; *La Ceramique*, **14**, 204. A part of the silicate of either the natural or artificial silicate of zirconium is removed by warming with alkali carbonate or hydroxide, which product is very suitable for rendering enamels opaque.

Landau, Kreidl, Heller and Co. White enamels. German Patent 283,504. June 23, 1911. *C. A.*, **9**, 2579. Addition to German Patent 274,860.

Landau, Kreidl, Heller and Co. White enamel with metal hydroxides as clouding agents. German Patent 289,102. Oct. 3, 1911.

Landrum, R. D. Resistance of sheet enamels to solution by acetic acids of various strengths. *Trans. Amer. Ceram. Soc.*, **13**, 494–501 (1911); *C. A.*, **5**, 3886; *J. Soc. Chem. Ind.*, **30**, 1386.

Mayer, M., and Havas, B. The coefficient of expansion of enamels and their chemical composition. *Sprechsaal*, **44**, 188–91, 207–10, 220–2 (1911); *C. A.*, **5**, 2163; *J. Soc. Chem. Ind.*, **30**, 543.

Mayer, M., and Havas, B. Reactions during the fusion of iron enamels (containing fluorine). *Sprechsaal*, **44**, 6–8 (1911); *C. A.*, **5**, 2163; *J. Soc. Chem. Ind.*, **30**, 930.

Meyer, A. Enameling or glazing plates of iron, steel, etc. German Patent 266,161, July 9, 1911. *C. A.*, **8**, 809.

Meyer, A. Enameled or glazed plates of iron or steel. German Patent 272,355, July 9, 1911. *C. A.*, **8**, 2612.

Minneman, Johannes. An investigation on art enameling on metals. *Trans. Amer. Ceram. Soc.*, **13**, 514–30 (1911); *C. A.*, **5**, 3890; *J. Soc. Chem. Ind.*, **30**, 1386.

Olsberger and Altenbekener Eisenhüttenwerke C. Kropff. Enameled cooking utensils. German Patent 244,389, Mar. 2, 1911. *C. A.*, **6**, 2304.

Rickmann, R. White pigments for enamels, etc. German Patent 283,204, Dec. 5, 1911. *C. A.*, **9**, 2444. Substances containing antimony are used.

Roenelt, T. J. Process of enamel stripping by heating with alkaline compounds. French Patent 434,301, Sept. 16, 1911. *J. Soc. Chem. Ind.*, **31**, 336. Potassium cyanide is used, sprinkled on the enamel heated to just redness. The enamel may be lifted off after half a minute.

Schott, E. A. Muffle oven for enamel works and other industrial purposes. *Stahl u. Eisen*, **31**, 310 (1911); *C. A.*, **5**, 2315.

Staley, H. F. The cause and control of the mottling of enamels on metals. *Trans. Amer. Ceram. Soc.*, **13**, 489–93 (1911); *C. A.*, **5**, 3890.

Tostmann, C. The function of the ground enamel. *Keram. Rundschau*, **19**, 5–6 (1911); *C. A.*, **5**, 1670. The claim is reasserted that in ground enamels on cast iron the cobalt oxide is reduced to cobalt.

Various processes for decorating enameled ware. *Glashütte*, **41**, 811–3, 839–40, 864–6; *C. A.*, **6**, 142.

Vondrácek, R. The function of the ground enamel. *Sprechsaal*, **44**, 115; *C. A.*, **5**, 2163.

Vondrácek, R. The enamel industry. *Sprechsaal*, **44**, 264–7 (1911); *C. A.*, **5**, 3503. A general review of the industry for 1910.

Waldes and Co. Enameling tools, etc. German Patent 242,850, Jan. 29, 1911. *C. A.*, **6**, 2157.

Zahn, O. Enameling muffles. *Keram. Rundschau*, **19**, 30–2 (1911); *Stahl. u Eisen*, **31**, 308–10 (1911); *C. A.*, **5**, 1671. A criticism of previous work on enamels.

1912

Akt. Ges. Porzellanfabr, Weiden Gebr. Bauscher. Method of enameling vessels. French Patent 451,332, Dec. 4, 1912. *C. A.*, **7**, 3210.

Brown, R. E. Replacement of tin oxide by antimony oxide in enamels for cast iron. *Trans. Amer. Ceram. Soc.*, **14**, 740–55 (1912); *C. A.*, **7**, 232; *J. Soc. Chem. Ind.*, **31**, 1129. A different type of enamel is required if antimony is used.

Dupont, P. Enameling bath tubs. German Patent 269,524, Sept. 26, 1912 *C. A.*, **8**, 2469. Heating of the tub is effected by electric means.

Enameling on metal. *Keram. Rundschau*, **20**, 79; *C. A.*, **6**, 3504.

Eyer, Ph. Natural history of enamel defects. *Keram. Rundschau*, **20**, 233–5, 243–5, 252–5. *C. A.*, **6**, 3505.

Goldschmidt, Th. Frits useful in the manufacture of enamels or glasses. French Patent 439,609, Feb. 1, 1912. *La Ceramique*, **16**, 12; *C. A.*, **7**, 1959; *J. Soc. Chem. Ind.*, **31**, 723.

Haschek, K. Decorating enameled metal products. German Patent 275,560, Dec. 28, 1912. *C. A.*, **9**, 852.

Heilmann, E. Opaquing substances for white enamels. English Patent 26,498, Nov. 18, 1912. *C. A.*, **8**, 1652; *J. Soc. Chem. Ind.*, **33**, 259. Mixtures of magnesium oxide and aluminium oxide or of aluminium oxide and zinc oxide, calcined to form a spinel.

Kralapp, E. Furnaces for the preparation of fritted enamels. *Keram. Rundschau*, **20**, 261–3; *C. A.*, **6**, 3505.

Kretzer, H. Process for the manufacture of clouded glasses, enamels, and similar products and of clouding agents allowing the carrying out of this process. French Patent 444,440, May 30, 1912. English Patent 12,749, May 30, 1912. *J. Soc. Chem. Ind.*, **31**, 1129.

Landau, Kreidl, Heller and Co. Clouding agent for white enamel. English Patent 11,754, May 17, 1912. *C. A.*, **7**, 3649.

Landau, Kreidl, Heller and Co. Alkali containing clouding agent for white enamels. German Patent 283,792, Aug. 24, 1912. *C. A.*, **10**, 262. Metal compounds, other than those of tin, are used.

Landau, Kreidl, Heller and Co. Clouding agents for white enamels. English Patent 16,787, July 18, 1912. *C. A.*, **8**, 410. Zircon is partially disintegrated by heating with sodium hydroxide or carbonate and the soluble silicates and surplus alkali removed with water. The combined alkali is partly removed by treating the mass with ammonium or metallic salts and the product then heated until the water of hydration is removed.

Landau, Kreidl, Heller and Co. Clouding white enamels. English Patent 19,849, Aug. 30, 1912. *C. A.*, **8**, 562.

Landau, Kreidl, Heller and Co. Iron enamels. German Patent 282,348, Aug. 10, 1912. *C. A.*, **9**, 2301. Method of directly enameling iron in white.

Landau, Kreidl, Heller and Co. Manufacture of white enamels. French Patent 429,665. First addition. June 6, 1912. *J. Soc. Chem. Ind.*, **31**, 1181. See English Patent 6,787.

Landau, Kreidl, Heller and Co. Opaquing agents for white enamels. English Patent 1,136, Jan. 15, 1912. *C. A.*, **7**, 2460.

Landau, Kreidl, Heller and Co. White enamels. Swiss Patent 62,594, July 8, 1912. *C. A.*, **8**, 2236. Alkali containing hydroxides of the known metal compounds, used heretofore as obscuring agents, are here employed for that purpose.

Landau, Kreidl, Heller and Co. White enamels. English Patent 29,382, Dec. 20, 1912. *C. A.*, **8**, 2046. The amount of water of hydration contained in the hydrated oxide used as the opaquing agent is varied in inverse proportion to the per cent of alkali used.

Landau, Kreidl, Heller and Co. White enamel. French Patent 438,908, Jan. 11, 1912. First addition, Jan. 18, 1912. French Patent 450,228, Sept. 7, 1912. English Patent 29,382, Dec. 20, 1912. *C. A.*, **7**, 3210; *J. Soc. Chem. Ind.*, **31**, 643; **32**, 489, 753. Compare the above patents by the same firm.

Landrum, R. D. A comparison of ten white enamels for sheet steel. *Trans. Amer. Ceram. Soc.*, **14**, 489–509 (1912) *C. A.*, **7**, 230; *J. Soc. Chem Ind.*, **31**, 1129.

Landrum, R. D. Enamels for sheet steel. *J. Ind. Eng. Chem.*, **4**, 561–4 (1912); *Chem. Eng.*, **16**, 141–3 (1912).

Landrum, R. D. The necessity of cobalt oxide in ground coat enamels for sheet steel. *Trans. Amer. Ceram. Soc.*, **14**, 756–67; *C. A.*, **7**, 232.

Rickmann, R. Testing of enamels containing antimony. *Z. angew. Chem.*, **25**, 1518–19 (1912); *J. Soc. Chem. Ind.*, **31**, 775. The sample is boiled for half an hour with 4 per cent acetic acid or 2 per cent tartaric acid. The antimony in solution is titrated with permanganate. The meta-antimonates are not attacked by this treatment.

Rickmann, R. Coloring agents for white glasses, glazes and enamels. English Patent 27,954, Dec. 4, 1912.

Rickmann, R. The use of antimony compounds for the production of white enamel. *Sprechsaal*, **45**, 115–7 (1912); *La Ceramique*, **15**, 134; *C. A.*, **6**, 1348, 2679; *J. Soc. Chem. Ind.*, **31**, 231. Antimony oxide should be avoided, but the antimonates are not injurious to health.

Rickmann, R. White covering for enamels. French Patent 451,238, Dec. 2, 1912. English Patent 27,954, Dec. 4, 1912. *C. A.*, **7**, 3210; *J. Soc. Chem. Ind.*, **32**, 604. Antimony is heated to redness with saltpeter and an alkaline hydroxide.

Schuler, A. J. Process for dulling enamels. English Patent 28,679, Dec. 12, 1912. *J. Soc. Chem. Ind.*, **33**, 81.

Shaw, J. B., and Shaw, Lucian. Determining the cost of enameled sheet steel cooking utensils. *Trans. Amer. Ceram. Soc.*, **14**, 510–5 (1912); *C. A.*, **7**, 230.

Staley, Homer F. The cause and control of crazing in enamels on cast iron. *Trans. Amer. Ceram. Soc.*, **14**, 516–45; *C. A.*, **7**, 230; *J. Soc. Chem. Ind.*, **31**, 1129.

White enamel with zirconium silicate base. *La Ceramique*, **14**, 204; *C. A.*, **6**, 1665. The natural silicate of zirconium, extracted with hydrochloric acid, and then with 4 parts of sodium hydroxide at 500–600 gives a product that is bulky and superior to tin oxide.

Zahn, O. Burning furnace for enameling. German Patent 263,518, Sept. 27, 1912. *C. A.*, **8**, 227.

1913

Advantages of the portable muffle furnace in glass, porcelain and enamel works. *Diamant*, **35**, 485–6; *C. A.*, **7**, 3003.

de Back, A. Removing enamels from waste enamel ware. English Patent 77, Jan. 1, 1913. *C. A.*, **8**, 2235.

Berge, A. Leadless enamels and faience with reduced content of tin oxide. *Sprechsaal*, **46**, 17–9(1913); *J. Soc. Chem. Ind.*, **32**, 142. Instead of dispensing with tin oxide, it is reduced to a minimum by fritting with sodium phosphate.

Bertrand, M. S. V. Enamels of sodium borosilicate. *La Ceramique*, **16**, 113–4; *C. A.*, **7**, 2841.

Chem. Fabrik Güstrow, Hillringhaus, and Heilmann. Opaquing agent for white enamels. English Patent 11,749, May 20, 1913. *C. A.*, **8**, 3622. This consists of titanic acid and zirconium oxide.

Davidson, T. R. Cleaning of metal articles preparatory to the application of a coating of enamel or the like. English Patent 16,554, July 18, 1913 *J. Soc. Chem. Ind.*, **33**, 355. Concentrated sulfuric acid is used to carbonize the grease, and the pieces are then allowed to stand in water, where the diluted acid further cleans the articles.

de Haen, E., Chem. Fabrik List G. m. b. H. Enamel and glazes. German Patent 289,317, Jan. 14, 1913. *C. A.*, **10**, 2792. Zinc sulfide is used as a substitute for the oxide.

Deleuil, S. L. Enameling metal plates. French Patent 456,959, Apr. 22, 1913. *C. A.*, **9**, 137. The plates, after immersion in the bath, are freed from excess by rapid turning.

Eyer, Ph. The assumed reduction of antimonic to antimonous compounds in enamels. *Glashütte*, **43**, 266, 327–8; *C. A.*, **7**, 3004. This does not take place.

Eyer, Ph. Design and equipment of an enameling plant. *Keram. Rundschau*, **20**, 433–5, 447–9, 538–40; **21**, 24–7, 47–9; *C. A.*, **7**, 2102.

Eyer, Ph. The melting of enamels. *Ill. Ztg. Blechind.*, **1912**, 640; *C. A.*, **7**, 2459.

Eyer, Ph. Quartz and clay in enameling. *Glashütte*, **43**, 662–3; *C. A.*, **7**, 3647.

Eyer, Ph. Scientific enameling. *Glashütte*, **42**, 8–43, No. 12 (1912–1913); *C. A.*, **7**, 3004. An exhaustive treatise.

Frissell, N. E. Enameling process for cast iron sanitary ware. *Foundry*, **41**, 220–3; *C. A.*, **7**, 3209.

Goldschmidt, Th. Removing enamel and recovering the iron, etc. French Patent 418,971. First addition, May 5, 1913. *J. Soc. Chem. Ind.*, **32**, 1072.

Havas, B. Manufacture of zirconium oxide. German Patent 262,009. May 5, 1913. *C. A.*, **7**, 3650.

Hirsch, W. Furnace for enameling. German Patent 283,869, Feb. 1, 1913.

Honigmann, L. Enamel for sheet metal and other hard surfaces. French Patent, 465,574, Dec. 1, 1913. English Patent 28,398, Dec. 9, 1913. *C. A.*, **8**, 3495; *J. Soc. Chem. Ind.*, **33**, 355. The use of metallic silver.

Importance of powdered coal in enamel works. *Glasshütte*, **43**, 1004–6; *C. A.*, **8**, 1194. The relative value of 3 varieties of charcoal and coal are discussed.

Influence of sulfur dioxide used as a disinfectant upon sheet steel enamel. *Keram. Rundschau*, **21**, 380; *C. A.*, **8**, 224. Dry or water-laden sulfur dioxide is without effect upon perfect ware, but on ware exhibiting crazing defects, yellow spots are formed in the defective spots of the enamel. If the ware itself is wet, however, the sulfur dioxide fumes exert vigorous effect, due to sulfuric acid formation.

Kentonwski, L. A muffle furnace for enameling large cast iron kettles. *Stahl u. Eisen*, **32**, 2179–80; *C. A.*, **7**, 2102.

Krause, H. Enamels. *Electrochem. Z.*, **20**, 113–6, 143–5, 176–9; *C. A.*, **8**, 805. Historical and descriptive article.

Landau, Kreidl, Heller and Co. Covering masses for white enamels. French Patent 456,335, Apr. 4, 1913. *C. A.*, **8,** 2047; *J. Soc. Chem. Ind.*, **32,** 945.

Landau, Kreidl, Heller and Co. Manufacture of white enamels. *La Ceramique*, **16,** 9–10; *C. A.*, **7,** 1961.

Landau, Kreidl, Heller and Co. Opaquing agents for white enamels. English Patent 17,998, Aug. 17, 1913. *C. A.*, **9,** 363. Highly basic compounds or complexes of aluminium, tin, titanium or zirconium, containing a small proportion of the radicals not refractory to heat.

Landau, Kreidl, Heller and Co. White, particularly zircon, enamels. French Patent 462,587, Sept. 16, 1913. German Patent 286,038, Oct. 25, 1912. English Patent 17,998, Aug. 7, 1913. *C. A.*, **8,** 3106; *J. Soc. Chem. Ind.*, **33,** 314, 921.

Landau, Kreidl, Heller and Co. White enamel. French Patent 463,623, Oct. 14, 1913. *J. Soc. Chem. Ind.*, **33,** 355; *C. A.*, **8,** 2788.

Landau, Kreidl, Heller and Co. White enamel. Austrian Patent 4,677,009, June 13, 1909. *C. A.*, **7,** 3209.

Landau, Kreidl, Heller and Co. White enamel. French addition, 17,112 to Patent 438,908, Jan. 18, 1913. *C. A.*, **8,** 411. Each hydrate unit gives its highest effect with a certain alkali amount which must be ascertained emperically.

Landau, Kreidl, Heller and Co. White enamels and opacifiers for white enamels. *La Ceramique*, **16,** 238–40; *C. A.*, **8,** 224. The opacifying effects of the metallic oxides are influenced by combinations with small amounts of phosphoric acid. Combining water of hydration and alkali or alkaline earths to the above phosphate further favorably influences the opacifying effect.

Landau, Kreidl, Heller and Co. White enamels of a zircon base. *La Ceramique*, **16,** 61–2; *C. A.*, **7,** 2671; *La Ceramique*, **17,** 52–3; *C. A.*, **8,** 2233.

Meyer, A. Enamel. English Patent 2,155, Jan. 27, 1913. *C. A.*, **8,** 2611.

Meyer, A. Enameling. English Patent 2,279, Jan. 28, 1913. *C. A.*, **8,** 2612. Coats of enamel of increasing fusibility are applied over the anti-oxide layer.

Michel, R. Iridescent enamel. French Patent, Addition 17,326 to 455,064, Feb. 7, 1913. *C. A.*, **8,** 2046. Glass or enamel ware, immediately after production, is exposed at a suitable temperature to metal bromide vapors.

Nailler, Raymond F. Art of enameling or the coating of iron and steel with glass. *Am. Soc. Mech. Eng.*, **35,** 1479–92 (1913); *Sci. Am. S.*, **76,** 338–9; *Met. and Chem. Eng.*, **11,** 695–8; *Iron Trade Rev.*, **53,** 678–80; *Iron Age*, **92,** 843–4 (1914); *Foundry*, **42,** 7–10; *Eng. Mag.*, **46,** 603–5 (1914); *C. A.*, **8,** 805. Deals with the fundamentals of sheet steel and cast iron enamels.

Removing enamels. *Glashütte*, **43,** 326–7; *C. A.*, **7,** 3004. The use of sodium hydroxide at 180° with 12 atmospheres pressure is suggested.

Schuler, A. J. Process for dulling enamels. Canadian Patent 146,740, Mar. 18, 1913. *C. A.*, **7,** 1792. A silicious material is mixed with the covering mass and burned in a furnace on the article to be enameled.

Schuler, A. J. Roughening of enamels. *La Ceramique*, **16**, 239–40; *C. A.*, **8**, 224. Quartz, feldspar or kaolin is mixed with a cover compound of earths or silicates and salts before application to the object.

Shaw, J. B. Process of making sanitary ware. *Trans. Amer. Ceram. Soc.*, **15**, 467–481; *C. A.*, **8**, 807.

Stanley, H. F., and Fisher, G. P. Leadless enamels. *Trans. Amer. Ceram. Soc.*, **15**, 620–7; *C. A.*, **8**, 805; *J. Soc. Chem. Ind.*, **33**, 80. Four good lead-free enamels were produced.

Weiss, L. Opaquing agents for enamels. French Patent 459,999, June 23, 1913. English Patent 14,632, June 24, 1913. *C. A.*, **8**, 2932; **9**, 136; *J. Soc. Chem. Ind.*, **32**, 1157. Fluorides or double fluorides of tin, antimony, titanium, zirconium are used. The effect is increased by the presence of hydroxides of the alkalies and alkaline earths or of silicon compounds.

Westfalische Stanz- und Emailliewerke Akt. Ges. vorm. J. and H. Kerkamm. Enamel glazes on iron. German Patent 289,103 Sept. 11.1 913. *C. A.*, **10**, 2511; *J. Soc. Chem. Ind.*, **35**, 424. Metal powder or dust is added to the ordinary enamel glaze.

Westfalische Stanz- und Emailliewerke Akt. Ges. vorm J. und H. Kerkamm. Enamel glazes on iron. German Patent 290,054, Nov. 4, 1913. *C. A.*, **10**, 2792. Water soluble metallic compounds which decompose at the enemeling temperature are used.

Zahn, O. Muffle furnace for enameling. German Patent 267,801, Feb. 27, 1913. Addition to German Patent 263,518.

Zahn, O. Process and firing oven, more especially applicable to enameling. French Patent, 460,104, July 7, 1913. *J. Soc. Chem. Ind.*, **33**, 25.

1914

Baumann, Gebr. Apparatus for clouding enamels. German Patent 286,037, Apr. 22, 1914. *C. A.*, **10**, 1701.

Berge, A. Enamel glazes free from lead and tin. *Sprechsaal*, **47**, 339–41; *C. A.*, **8**, 3493; *J. Soc. Chem. Ind.*, **33**, 647. Antimony compounds are used as a substitute for the more costly tin oxide in producing opacity. Formulas are given.

Berndt, M. The status of cobalt in ground coat of sheet steel enamel. *Keram. Rundschau*, **1914**, 262; *Silikat-Z.*, **2**, 160–1; *C. A.*, **8**, 3847.

Denmead, W. A. Hints on experimental enamel making. *Trans. Amer. Ceram. Soc.*, **16**, 445–53; *C. A.*, **8**, 3711. Practical guide for the production of enamels maturing at 700–1000°.

Dichanz, G. Securing enameled metal plates to each other. German Patent 286,774, Nov. 13, 1914. *C. A.*, **10**, 1587.

Don'ts relative to enameled iron ware. *Metal Work*, **82**, 410–1 (Sept. 18, 1914).

Eyer, Ph. Use of sodium silicofluoride in enamel glazes and in the glass industry. *Glashütte*, **44**, 205–7(1914); *C. A.*, **8**, 2468.

Eyer, Ph. White clouding materials for enamels. *Glashütte*, **44**, 247–9, 268–9; *C. A.*, **8**, 2469.

Haber, F. Zirconium oxide replaces stannic oxide in the enamel industry. *J. Ind. Eng. Chem.*, **6**, 326 (Apr., 1914).

Kraze, F. The technic of iron enamels applied dry. *Sprechsaal*, **47**, 535–8, 545–6 (1914); *C. A.*, **9**, 957.

Linke, Wilh. The plan and management of a modern enameling factory. *Glashütte*, **44**, Nos. 14–52; and **45**, Nos. 1–36; *C. A.*, **10**, 513.

Manufacture of gray enameled ware. *Iron Age*, **94**, 10–3 (July 2, 1914).

Musiol, C. Process of enameling sheet iron and cast iron articles by means of enamels free from boric acid and composed of silicates of aluminium, soda, and lime, containing fluorine. French Patent 473,395, June 12, 1914. *J. Soc. Chem. Ind.*, **34**, 493.

Nagel, Oskar. Some American enameling ovens. *Chem.-Ztg.*, **38**, 801–2; *C. A.*, **8**, 3105.

Shaw, J. B. Fluorides as opacifiers. *Trans. Amer. Ceram. Soc.*, **16**, 577–9; *C. A.*, **8**, 3713; *J. Soc. Chem. Ind.*, **33**, 1048.

Vondracek, R. Covering power of clouding agents for enamels. *Sprechsaal*, **47**, 341–2; *C. A.*, **8**, 3493; *J. Soc. Chem. Ind.*, **33**, 647. Water and alkali containing forms of the oxides of tin, zirconium and titanium are used. The increased covering properties are probably due to the oxides being in a state of a colloidal gel.

Welte, H. Support for the galvanic production of patterns in the ceramic and enamel industries. German Patent 283,081, Jan. 17, 1914. *C. A.*, **9**, 2444.

1915

Bartlett, C. W. Electrically heated enameling ovens. *Gen. Elec. Rev.*, **18**, 1130–6; *C. A.*, **10**, 679.

Bole, G. A., and Howe, R. M. Role of chlorides in the volatilization of ferric iron (from enamels). *Trans. Amer. Ceram. Soc.*, **17**, 125–9; *J. Soc. Chem. Ind.*, **36**, 879.

Electric enameling ovens. *Am. Machinist*, **43**, 598–600; *C. A.*, **9**, 2974.

Eyer, Ph. Antimonates. Enamel and glazes. English Patent 11,083, July 30, 1915. *C. A.*, **11**, 198; *J. Soc. Chem. Ind.*, **35**, 839. The production of antimonates is described.

Kardos, E. Method of removing enamel and like coatings from waste enamel and like ware. English Patent 100,118, Mar. 2, 1915. *J. Soc. Chem. Ind.*, **35**, 470.

Kraze, F. Saltpeter replacement in the enamel industry. *Keram. Rundschau*, **23**, 5–6; *C. A.*, **9**, 3341.

New opacifier for white iron enamels. *Keram. Rundschau*, **23**, 221–2; *C. A.*, **10**, 1416. Magnesium oxide and aluminium oxide, or zinc oxide and aluminium oxide.

Poste, Emerson P. The relative action of acids on enamels. *Trans. Amer. Ceram. Soc.*, **17**, 136–49 (1915); **18**, 762–3 (1916); *C. A.*, **11**, 282; *J. Soc.*

Chem. Ind., **36,** 879. Within a rather narrow limit in sizing, reasonable uniformity can be obtained in the loss in weight of a two-gram sample of frit ground to pass 20 mesh when exposed to a given solution.

Schaefer, J. Enamel and its use in the chemical industry. *Z. angew. Chem.*, **28,** I, 419–20; *C. A.*, **10,** 260. History of the industry and a general description of enamels and enameling methods.

Schroder, E. Muffle kiln for enamels. German Patent 296,457, Oct. 31, 1915. *J. Soc. Chem. Ind.*, **36,** 596.

Schwarzbach. A hint from enamel technology. *Diamant*, **37,** 525–6; *C. A.*, **10,** 960. To secure uniform and complete fusion the addition of borax, magnesium oxide, or ammonium chloride is recommended.

Staley, H. F. Antimony compounds as opacifiers in enamels. *Trans. Amer. Ceram. Soc.*, **17,** 173–89; *J. Soc. Chem. Ind.*, **36,** 879.

Tostmann, C. Saltpeter replacement in the enamel industry. *Keram. Rundschau*, **23,** 15 (1915); *C. A.*, **9,** 3341.

Using electric ovens for enameling. *Iron Trade Rev.*, **57,** 215 (July 29, 1915).

Vogel, H. The enameling of cast iron ware. *Keram. Rundschau*, **23,** 109–10; *Z. angew. Chem.*, **28,** Ref. 411; *C. A.*, **10,** 377; *J. Soc. Chem. Ind.*, **34,** 1145.

1916

Bickmeier, C. Continuous furnace for burning enamel ware. Canadian Patent 172,606, Oct. 17, 1916.

California sanitary enameled ware plant. *Metal Work*, **86,** 273–4 (Sept. 1, 1916).

Black enamels. Schnurpfeil's *Rev. Glass Works*, **2,** 137 (1916); *C. A.*, **10,** 2133. Five formulas are given.

Conover, W. R. Electric ovens and furnaces. *Am. Machinist*, **45,** 316–7 (1916); *C. A.*, **10,** 2543.

Danielson, R. R. The effect of variation in the composition of ground coats for sheet iron enamels. *Trans. Amer. Ceram. Soc.*, **18,** 343–62 (1916); *C. A.*, **11,** 283; *J. Soc. Chem. Ind.*, **36,** 717.

Heilmann, E. White enamels. Austrian Patent 72,232, Aug. 10, 1916. *C. A.*, **11,** 880. Mixtures of zinc and aluminum oxides or of magnesium and aluminum oxides are heated to form a spinel.

How enameled kitchen ware is made. *Iron Trade Rev.*, **59,** 1091–7 (Nov. 30, 1916).

Koepp, R., and Co. Enamels. English Patent 100,777, Feb. 18, 1916. *C. A.*, **10,** 2791; *J. Soc. Chem. Ind.*, **37,** 924A. Glass with low melting point is used to replace the usual fluxes.

Koepp, R., and Co. Manufacture of enamels. English Patent 101,221, Aug. 16, 1916. *J. Soc. Chem. Ind.*, **36,** 291. Enamels are clouded or rendered opaque by the addition of zirconium borate supersaturated with zirconia.

Koepp, R., and Co. Enamels. English Patent 101,802, Feb. 18, 1916. *C. A.*, **11,** 294; *J. Soc. Chem. Ind.*, **36,** 388. The use of natural borates is facilitated by the addition of large quantities of glass.

Koepp, R., and Co. Production of enamels. English Patent 107,392, Mar. 28, 1916. *J. Soc. Chem. Ind.*, **36,** 963. The addition of cobalt, nickel, manganese, copper or other oxide to an enamel greatly increases its adhesion.

Lotterhos, G. Enamels. Swiss Patent 72,174, Apr. 17, 1916. *C. A.*, **10,** 2511. Low melting glazes containing flux are used as a substitute for the fluxes containing boron.

Lynde, Charles C. Production of stamped and enamel ware. *Steel and Iron*, **50,** 211–5 (1916).

Poste, Emerson P. Heat transmission of enamel. *Trans. Amer. Ceram. Soc.*, **18,** 570–4; *C. A.*, **11,** 284; *J. Soc. Chem. Ind.*, **36,** 718.

Zinc sulfide as an opacifying agent. *Keram. Rundschau*, **24,** 5, 29 (1916); *C. A.*, **11,** 3106. Addition of not more than 5 per cent of zinc sulfide produces opaque enamels.

1917

Continuous enameling and stoving machine for small parts. *Engineering*, **103,** 410 (1919); *C. A.*, **11,** 2146.

Electric enameling ovens at Ford Plant. *Elec. Rev. West. Elec.* **71,** 407-409 (1917); *C. A.*, **11,** 3450. Detailed account of a modern large scale enameling installation.

Kretzer, H. Clouded enamels and glasses. Swiss Patent 73,471, May 1, 1917. *C. A.*, **11,** 3406. Silicon compounds of acid character are added to the enamel mass after melting and while grinding.

Later, E. P. Protective coatings; japans and enamels. *Foundry*, **45,** 139–40 (April, 1917).

Lotterhos, G. Enamel. Danish Patent 22,409, Sept. 3, 1917. *C. A.*, **12,** 413. Borax is replaced by glass containing easily fusible fluxes.

Poste, Emerson P. Enamel surfaces under the microscope. *Trans. Amer. Ceram. Soc.*, **19,** 146–59 (1917); *C. A.*, **12,** 523; *J. Soc. Chem. Ind.*, **37,** 513A.

Schaeffer, J. The use of zinc sulfide in white and luminous enamels. *Keram. Rundschau*, **25,** 75; *C. A.*, **12,** 2677; *J. Soc. Chem. Ind.*, **37,** 584. In sheet steel enamels of suitable composition zinc sulfide is an excellent opacifier in the absence of metallic oxides which tend to decompose it. The opacity is equal to that produced by stannic oxide, but the enamels are not so white nor brilliant.

Scott, W. S. The control of industrial heating units. *Elec. J.* **14,** 252–254 (1917); *C. A.*, **11,** 2618. An illustrated description of electrical units used in ovens for japanning and enameling.

Shaw, J. B. American clays for floating enamels. *Trans. Amer. Ceram. Soc.*, **19,** 339–60 (1917); *J. Soc. Chem. Ind.*, **37,** 512.

Verein Chem. Fabrik Landau. White enameling. Swedish Patent 41,858, Jan. 10, 1917. *C. A.*, **11,** 1735. The clouding agent is an anhydrous zirconium compound, poor in alkali, which is treated with salts of metals whose hydroxides or oxides themselves produce clouding effects.

Warge, K. Enameled metal articles. English Patent 116,361, June 11, 1917. *C. A.*, **13**, 79.

1918

Cast iron enameled ware. *J. Am. Ceram. Soc.*, **1**, 74–5 (1918); *C. A.*, **12**, 2117. Editorial.

Dreissen, Cl. G. Enamels and ceramic pigments. *Pol. Weekblad*, **1918**, Nos. 5, 6, 8; *Chem. Weekblad*, **16**, 865–6; *C. A.*, **13**, 2115. Review.

Frost, Leon J. The action of acetic acid solutions of different strengths on a sheet steel enamel. *J. Am. Ceram. Soc.*, **1**, 422–8 (1918); *C. A.*, **13**, 175; *J. Soc. Chem. Ind.*, **38**, 107A. Twenty to 25 per cent acid is the most corrosive.

Kreutzberg, E. C. How high grade enameling is done. *Iron Trade Rev.*, **63**, 1290–1 (Dec. 5, 1918).

Poste, Emerson P. The manufacture of enameled lined apparatus. *Chem. Met. Eng.*, **19**, 400 (Sept. 25, 1918); *C. A.*, **12**, 2676. Descriptive article of the general manufacturing operations.

Poste, Emerson P, and Rice, B. A. The effect of the degree of smelting on the properties of a frit. *J. Am. Ceram. Soc.*, **1**, 221–37 (1918); *J. Soc. Chem. Ind.*, **38**, 15A.

Shaw, J. B. Antimony oxide as an opacifier in cast-iron enamel. *J. Am. Ceram. Soc.*, **1**, 502–13 (1918); *C. A.*, **13**, 253; *J. Soc. Chem. Ind.*, **38**, 107A.

Staley, Homer F. The control of luster in enamels. *J. Am. Ceram. Soc.*, **1**, 640–7 (1918); *C. A.*, **13**, 775; *J. Soc. Chem. Ind.*, **38**, 140A.

Staley, Homer F. Enamels for cast iron. *J. Am. Ceram. Soc.*, **1**, 703–9 (1918); *C. A.*, **13**, 1000; *J. Soc. Chem. Ind.*, **38**, 176A.

Staley, Homer F. Ground coat enamels for cast iron. *J. Am. Ceram. Soc.*, **1**, 99–112 (1918); *C. A.*, **12**, 2117; *J. Soc. Chem. Ind.*, **38**, 15A.

Staley, Homer F. Preparation and application of enamels for cast iron *J. Am. Ceram. Soc.*, **1**, 534–55 (1918); *C. A.*, **13**, 253.

1919

Collins, W. D. Acid test on enamel ware. *J. Ind. Eng. Chem.*, **11**, 757–9 (1919); *J. Am. Ceram. Soc.*, **2**, 843; *J. Soc. Chem. Ind.*, **38**, 903A.

Danielson, R. R. Cleaning of sheet steel and iron for enameling purposes. *J. Am. Ceram. Soc.*, **2**, 883–94 (1919); *C. A.*, **14**, 1201.

Dupont, P. Enameling metal articles and furnace therefore. English Patent 114,618. *J. Soc. Chem. Ind.*, **37**, 700A.

Poste, E. P. The manufacture of enameled lined apparatus. *J. Am. Ceram. Soc.*, **2**, 944–76 (1919); *C. A.*, **14**, 1744.

Poste, E. P. Relative action of acids on enamels. II. *J. Am. Ceram. Soc.*, **2**, 32–43 (1919); *C. A.*, **13**, 1136; *J. Soc. Chem. Ind.*, **38**, 287A. Twenty per cent acid has the maximum effect. Citric and tartaric acids are more active than acetic acid.

Schorry, V. S. Magnesia as an opacifier (of enamels). *J. Am. Ceram. Soc.*, **2**, 447–80 (1919); *J. Soc. Chem. Ind.*, **38**, 635A.

Springer, L. What precautions should be taken in replacing soda or potash (in glasses and enamels). *Sprechsaal* **52,** 362–3 (1919); *C. A.*, **14,** 809; *J. Soc. Chem. Ind.*, **38,** 902A.

Treischel, Chester. The cause and control of blistering in sheet-steel enamels. *J. Am. Ceram. Soc.*, **2,** 774–81 (1919); *C. A.*, **14,** 107. Experiments show that hydrogen has much to do with this.

Vielhaber, L. Fuel consumption of muffle kilns in the enameling industry. *Keram. Rundschau*, **27,** 293–4 (1919); *C. A.*, **14,** 811; *J. Am. Ceram. Soc.*, **3,** 83–5 (1920); *J. Soc. Chem. Ind.*, **38,** 862A.

1920

Landrum, Robert D., and Frost, Leon J. Titanium enamels. *J. Am. Ceram. Soc.*, **3,** 316–21 (1920); *C. A.*, **14,** 2688. The good qualities resulting from the use of titanium seem to more than offset the bad ones and it seems possible to overcome some of the difficulties and develop enamels of very substantial practical value.

Lindemann, W. C. The electric cleaning of metals for enameling purposes. *J. Am. Ceram. Soc.*, **3,** 252–5 (1920). The electric cleaning process is superior to the older scaling or burning off method.

Metallic coating for the rust proofing of iron and steel. Bureau of Standards, *Circ. No.* **80**; *J. Am. Ceram. Soc.*, **2,** 844.

Shaw, J. B. Fish scaling. *J. Am. Ceram. Soc.*, **3,** 489–97 (1920); *C. A.*, **14,** 2689. Chemical composition has very little bearing on the subject of fish scaling. It is probably due to a number of contributory causes, which are discussed.

INFORMATION DEPARTMENT
ARTHUR D. LITTLE, INC.
CAMBRIDGE, MASS.

NOTICE—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

NOTE ON SILICA BRICK*

D. W. Ross

Considerable work has been done on the thermal expansion of the various forms of silica, and upon the phenomena attending the transformation of one form into another through the influence of heat. It is possible, however, that not many careful studies have been made of the combined effects of the above, as they occur in the crowns of industrial furnaces. It has been the writer's good fortune to have an opportunity to become familiar with such a case, and we believe it is of sufficient interest to silica brick users to bear repeating.

The plant in question consists of several tank furnaces used in the manufacture of bottle glass. These furnaces are equipped with regenerators in which the fires are reversed every 20 minutes. Each tank covers approximately 20 by 60 feet of floor space. The supports for the silica-brick crowns of the tanks are independent of the side walls, so that the side walls may be removed without changing crowns.

This plant has been in operation for a number of years, and during this time rough data have been kept concerning the silica brick crowns. To this end a horizontal straight edge has been placed over the center of each furnace and parallel to the axis of the crowns, but independent of the furnace. These serve as a means of measuring the rise of the crowns during heating. The expansion across any crown is measured either by the number of threads let out at the tie rods, or by direct measurement between opposite buckstays.

From observations during the extended period that the plant has operated, some general conclusions have been arrived at. These may be briefly summarized as follows:

1. That great care is necessary in heating up a new crown, due both to large expansion of the whole crown and to unequal

* Received Feb. 27, 1920.

expansion from place to place; some spots expanding considerably more than others.

2. That after 18 months (or more) service a crown can usually be cooled without disruption, providing the temperature is kept from dropping too suddenly after the fires are turned off.

3. That a crown so cooled can be reheated and during reheating gives less trouble than it did when it was first heated up. For on reheating, crowns, roughly speaking, only expand one-half (0.5) as much as they did during the first heating, and local non-uniformity is practically absent. Hence, reheating can be conducted considerably more rapidly than the original heating, without causing trouble.

4. That when a crown has been cooled after being in use 18 months a large percentage of the brick are broken in two, or at least contain a zone of weakness approximately midway between the inside and outside of the crown.

Microscopic examination of portions of the interior of a used crown (approximately 18 months service) indicated that it was practically all tridymite but contained a slight amount of calcium monosilicate crystals scattered through it and a slight amount of glass. It is possible that there was a trace of cristobalite present, but no quartz, whatever was reported. The inner tridymite portions were practically pure white, while the zone immediately back of this was of a darker reddish tan color than is found in most unused silica brick. The outside of the crowns never get hot enough to allow much changing of the silica from one form to another, and silica brick received from the manufacturer are largely cristobalite and quartz.[1]

From the above it seems probable that in reheating used crowns, the lesser expansion and the ability to withstand more rapid heating than was permissible with the crown when new, is on account of the silica of the inner part of the crown being almost wholly in the form of tricymite. The local non-uniformities of expansion in new crowns are in all probability caused by non-uniformities of burn of the brick when manufactured.

Cosmo Johns[2] has said that the breaking of silica brick ap-

[1] U. S. Bureau of Standards, *Tech. Paper* **116**, (1919).

[2] Cosmo Johns, *Journ. Soc. Glass Tech.*, **1**, 137 (1917).

proximately midway between the interior and exterior of used crowns is in a narrow field in which the inversions vary back and forth with fluctuations of the temperature of a crown while the furnace is in heat.

It appears possible that the fact that one end of such brick is largely tridymite while the other end is mostly quartz and cristobalite may also have a very important bearing upon this cracking of the brick at or near the middle.

The effect of migration of iron, and so forth, from one part of a silica brick to another, while in use, as noted by Rengade[1] may also exert an influence.

FINDLAY CLAY POT CO.
WASHINGTON, PA.

NOTICE—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

[1] E. Rengade, Acad. of Sci., Paris, May, 1918. Reference obtained from *J. Ind. Eng. Chem.*, **12**, 1148 (a paper by W. F. Rochow).

CORRECTION

A High-Temperature Transverse-Strength Test as a Method of Testing Sagger Mixtures, S. C. Linbarger and C. F. Geiger, THIS JOURNAL, Vol. **3**, 548, line 23 for "at 1200°" read "at 1300°."

CHARLES F. GEIGER.

CERAMIC ABSTRACTS[1]

General

A rapid method for the relative porosity determination of ceramic bodies. LÉON BERTRAND, *Céramique*, **23**, 77 (1920); *Sprechsaal*, **53**, 443–444 (1920). —The customary method for determining the porosity is by the formula $\frac{P_1 - P_0}{P_1 - P_2}$ in which P_0 = dry weight, P_1 = wet weight and P_2 = suspended weight. In using this method it is necessary to determine 3 weights whereas in the new method it is only necessary to know 2 weights. In making the suspended weight the test piece is immersed under a liquid by means of a wire. A small additional pan is attached to this wire to determine the difference between P_0 and P_1. The test piece is attached to the wire and the scale is balanced by putting weights on the opposite large scale pan. The test piece is then immersed in the liquid and after all absorption has ceased the scale is again balanced by putting weights on the small scale pan. This weight equals $P_0 - P_1$. The saturated test piece is now removed from liquid, wiped and again attached to wire and the weights are removed from the small scale pan. The balance is again balanced by putting additional weights on the large scale pan. These addition weights equal $P_1 - P_0$. Let $p' = P_0 - P_2$ and $p'' = P_1 - P_0$. The porosity is then $\frac{p''}{p' + p''}$. For this work it is desirable to use carbon tetrachloride because of its low surface tension. It was found that $^1/_4$ hr. was usually sufficient to completely saturate the test pieces and in no case was more than 2 hrs. necessary whereas with water it is often necessary to soak 24 hrs.

H. G. SCHURECHT.

The shrinkage, porosity and other properties of a china clay after being fired at various temperatures. MISS E. M. FIRTH, F. W. HODKIN, W. E. S. TURNER. *Jour. Soc. Glass. Tech.*, **4**, 264–7.—The material used was a typical commercial English china clay, the calculated analysis of which indicated that it consisted of 87 per cent kaolinite, 11 per cent orthoclase with small amounts of other minerals. The clay was made up with $49^1/_2$ per cent water

[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the editor of Chemical Abstracts by coöperative agreement.

to a very smooth and fairly plastic mass. The properties at various temperatures were as follows:

Firing temperature °C	Shrinkage	Porosity	Apparent density	True density
110	3.30	..	..	..
200	.32	..	..	..
350	.38	..	..	..
500	.61	..	..	..
600	.92	51.5	1.20	2.46
750	4.14	52.5	.19	.53
900	.48	56.2	.14	.56
1000	5.72	52.0	.25	.62
1100	10.94	45.6	.41	.60
1200	14.71	31.7	.77	.60
1300	18.72	14.5	2.19	.56
1400	21.15	8.3	.36	.56
1500	22.08	2.4	.44	.51

E. RODGERS

The human factor in industry. G. H. MILES. *Jour. Soc. Glass Tech.*, **4**, 267–281.—A general discussion of the subject in which special emphasis is laid on the employment of modern psychological tests in vocational training and guidance. This was followed by a description of the National Institute of Psychology and Physiology which is now being established in England for the purpose of research in the field of vocational guidance and industrial psychology and applying the results to industry. E. RODGERS.

Refractories

Strength of refractories at different temps. V. BODIN. *Ceramique*, **23**, 177–184 (1920).—The strength of refractories at different temps. were measured on $^3/_8$" cubes heated in a gas furnace. It was found that for fire-clay, bauxite, corundum, carborundum, silica and zirconia refractories the crushing strength decreases with an increase in temp. up to about 800° C. Above this temp. the strength increases rapidly with an increase in temp. until about 1000° C. is reached, after which the strength again decreases with an increase in temp. With magnesite and chrome refractories the strength decreases with an increase in furnace temp. showing no increase in strength at 1000° C. For ex. a bauxite having the following chem. analysis was fired at 1300° C. and 1500° C. after which it was tested at different temps.: SiO_2 13.3, TiO_2 3.35, Al_2O_3 61.05, Fe_2O_3 4.75, CaO 0.95, MgO 0.10, SO_3 trace and loss on ignit. 16.45:

Temp. °C	Kilograms per cm². Bauxite fired at 1300° C	Bauxite fired at 1500° C
20	395	660
600	300	380
700	285	350
800	270 minimum	360 minimum
900	350	570
1000	715 maximum	685 maximum
1100	330	500
1200	120	260
1300	55	95
1400	30	40
1500	15	15

Tests made on other refractories gave the following results:

Type	Compress. strength kgs. cm². 20° C	800° C	1000° C	1300° C	1500° C
Fire-clay A	195	125	105	740	40
Fire-clay C L	920	555	575	360	65
Fire-clay P	1110	485	755	115	20
Corundum	790	530	615	310	30
Carborundum	415	425	585	150	70
Silica brick S	180	90	80	60	40
Silica brick V	240	125	185	160	100
Fused quartz	2550	1040	780	1670	100
Zircon	395	275	345	90	10
Magnesite	450	205	190	155	30
Chrome	450	450	425	215	75

H. G. SCHURECHT.

Electric furnace refractories. A. F. GREAVES-WALKER. *Chem. Met. Eng.*, **23**, 933–36.—The basic refractories available for making electric furnace linings are magnesite, dolomite, zirkite, alundum, carborundum, bauxite. The neutral are chromite, zircon, carbon, and fire-clay. Silica is the only acid refractory given. The properties of these various refractories are discussed briefly. The refractories recommended for melting various metals are: steel ingots and castings, magnesite for high grade steels, silica for ordinary steels or when selected pure scrap is used; alloy steels, magnesite exclusively; ferromanganese, magnesite or carbon; ferrochrome, magnesite or chrome; ferrosilicon, silica; cast iron, fire-clay for low temperature melting, silica for high temperature melting, magnesite on irons of special low sulphur and phosphorous requirements; copper, magnesite on bronze scrap or pig containing lead, silica or magnesite on refined pig and pure scrap; bearing metal, magnesite with as low silica as possible; monel metal, magnesite preferable but silica can be used; bronze, silica preferable but magnesite can be used where zinc is not too high; lead, magnesite exclusively; silver, silica; aluminum

and its alloys, magnesite exclusively. Many of the failures of refractories in electric furnace linings are due to poor construction and especially failure to provide sufficiently numerous expansion joints. In many cases refractories are ruined by improper handling and exposure to weather before they are placed in service. A. J. LAMBERT.

Refractories for electric furnaces. ANON. *Mineral Foote-Notes*, Sept.-Oct., 3–7 (1920).—Electric furnaces may be roughly divided into two classes, namely, those for ferrous and those for non-ferrous metals. For ferrous melting the arc furnace in its various modifications is in general use. In non-ferrous industries, arc, radiation and induction furnaces are in use. The non-ferrous furnaces are low temp. units when compared with those used in the ferrous industries since the aim in non-ferrous furnaces is to work at minimum temps. so as to avoid volatilization losses. Furthermore, non-ferrous furnaces are intended for melting only whereas ferrous furnaces are intended for refining as well as melting which means a more vigorous slag action on the refractories. Some special requirements for electric furnace refractories are the following: (1) The melting point should be between 1700° to 1750° C. (2) They should be very resist. to sudden temp. changes since a heat is often completed 2 hrs. after starting from the cold. (3) The refractories should not change in volume at electric furnace temps. Brick fired in fuel-fired kilns often shrink considerable when fired at the higher electric furnaces temps. (4) The brick should be very resist. to corrosion since oxidizing and reducing slags are often present and these together with the high temps. cause vigorous corrosion of the refractories. (5) Where a circulating metal bath is used as in induction furnaces the refractories should be very resist. to abrasion. Different parts of the furnaces must meet the following requirements: (*a*) The outer walls should be a good heat insulator and moderately refractory. (*b*) The hearth should have a high melting point, be inert towards slags and be resist. to erosion. (*c*) The roof should be resist. to slags and fumes, should have no tendency to spall and have a high melting point. The present practice is to use a good grade of fire-brick for the outer wall, this sometimes being laid next to silocel, asbestos or a similar insulator. Magnesite brick are laid against the fire-brick for forming the inner side walls of the furnace and one or two coarses are laid over the bottom layer of fire-brick. The rammed in or built up hearth is then built in with dead-burned magnesite, dolomite or "syndolag." The roof is most frequently made of silica brick, although carborundum and electrically fused magnesite have also been used. The refractories now used in electric furnaces fail to meet the requirements. It is suggested that zirkite may be an excellent refractory for electric furnaces since it meets most of the above requirements. H. G. SCHURECHT.

Glass

Note on the density of soda-magnesia glasses. C. J. PEDDLE. *Jour. Soc. Glass Tech.*, **4**, 281–3.—The density of a series of glasses containing five molecules of SiO_2 were found to be as follows:

Molecules		
Na_2O	MgO	Density
1.75	0.25	2.453
.625	.375	.448
.50	.50	.444
.375	.625	.439
.25	.75	.433
.00	1.00	.421

From a study of these results and comparison with those obtained by Turner (see THIS JOUR., **3**, 927) the following conclusions were drawn: In glasses where the molecular SiO_2 and Na_2O content remains constant, increasing the molecular content of either MgO or CaO raises the density. Where the SiO_2, MgO or SiO_2, CaO content is the same in two glasses, the one with the higher molecular Na_2O content will have the higher density. The rate of increase of density per molecule of CaO added is much greater than the rate of increase per molecule of MgO added. The rate of increase of density diminishes in both the MgO and CaO glasses as the amount of magnesia or lime increases, and this diminution is most marked in the series containing the most Na_2O. In two like series of CaO and MgO glasses, the lime glasses have a higher density than the magnesia glasses. E. RODGERS.

Expansion of glass at high temperatures. W. B. PIETENPOT. *Chem. Met. Eng.*, **23**, 876–7.—Expansion of various glasses in strips 76 cm. long was measured from room temperature to 750° C. The rate of expansion of annealed glass is nearly linear up to temperatures of 450 to 550° C. depending upon the kind of glass. The rate of expansion then increases by four to six times, through a temperature range of 60 to 100° C. After the rapid increase in expansion the rate of expansion again becomes nearly linear, in general being slightly greater than at low temperatures. When the softening point is reached the rate of expansion gradually decreases and the length of the strip remains constant. At this point the glass loses its form. With unannealed glass the rate of expansion in general decreases from 50 to 150° before the rapid expansion takes place. This decreased rate may continue through a temperature range of 100 to 150°, depending upon the strain in the glass. In some instances the expansion through a range of 100° is practically zero. Upon cooling, the strip of glass is shorter by a definite amount which is proportional to the strain which has been relieved. A. J. LAMBERT.

The factory inspection of glassware. W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **4**, 253–61.—According to the class of ware being made, tests from the following list should be applied: poor color; uniformity of weight; uniformity of capacity, test of size of neck by a standard gauge; uniformity of thickness; cracking test; determination of bursting pressure; accuracy of graduation; absence of seeds, blisters, and cords; examination in the polaris-

cope for state of annealing in the case of glass other than dark metal. The cracking test is applied by filling the bottle with water, heating it slowly to not less than 70°, and chilling it suddenly in water at 20°, afterwards repeating the test at 75° and 80° if the bottle has not previously been cracked. Good bottles should withstand sudden chilling from 75° to 20° without cracking. The cracking test is really a test both of the uniformity of thickness and of the state of annealing, and is the only method of obtaining evidence on the state of annealing when the bottle is too dense in color to permit of examination by the polariscope. E. RODGERS.

On certain surface effects in glass, probably produced by reheating in the glory hole. MORRIS W. TRAVERS. *Jour. Soc. Glass Tech.*, **4**, 284–6.—In glasses that have been worked in glory holes, small bubbles appear immediately below the outer surface. It is suggested that this is due to the evolution of dissolved gases due to the fact that the surface of the glass is intensely heated by radiation from the burning coal or coke, the glass as a whole being opaque to radiation. A. J. LAMBERT.

Automatic feeding devices for glass-making machinery. HOMER BROOKE. *Jour. Soc. Glass Tech.*, **4**, 296–8.—The utilization of a flowing stream of molten glass from the furnace and cutting from it predetermined quantities of glass at a definite rate (30 to 90 per minute), the portions of glass then being served to automatic machines to make ordinary articles of glassware, has been successfully carried on for a number of years in the United States and Canada under patents granted to the author in the United States, Canada, Great Britian, France, Belgium, and Germany. The patents have now expired and are therefore open to all. A. J. L.

Casting of pots for use in experimental work on optical glass. ALICE B. TAYLOR. *Jour. Soc. Glass Tech.*, **4**, 251–3.—Reply to discussion. In pots cast under pressure the total shrinkage after firing to 1480° is less than that of the same slip cast in the usual manner with the same proportion of alkali. The drying shrinkage is very much less. Bubbles in the base of the pots occurred only when slip below a certain viscosity was used and where the time of filling was very rapid. The appearance of the bubbles and their position indicate an encircling and entrapping of air in the mold by the back wash of the slip after striking against the core of the mold. Since rapidity of rise is an asset in assuring even distribution of grog and clay, enough pressure was put on to send the slip up quickly but smoothly without splashing. It was then reduced somewhat. If a pressure of 15 to 25 lbs. per sq. in. is maintained for a considerable time there is a tendency for the pot to crack upon the core. E. RODGERS.

Some developments in the study of glass technology in the year 1919–1920. W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **4**, 287–96.—This comprises the 4th annual report of the Delegacy for Glass Research. The year's work has been marked by steady development rather than by outstanding events.

Thirteen papers dealing with glass research have been published. In addition five others were read before the Society of Glass Technology and will be published later. One hundred and fifty-eight cases of inquiry from glass manufacturers have been dealt with. Sixty-eight of these involved more or less experimental work. Twenty-three students have been taking full time university courses. Local center courses have been carried on at Barnsley, Leeds, London, Mexboro and Sheffield. Ninety-four students were enrolled in these classes. Six lectures were given to an average attendance of 200 persons at Stourbridge. Fifty-nine students, practically all disabled soldiers, were enrolled in the lamp working school. Fifty-two hundred pounds were expended and £4500 received for the Delegacy work leaving a deficit of £700. Among the contributors to the fund were five glass manufacturers associations. A. J. LAMBERT.

Device for measuring the internal diameter of glass tubing. VERNEY STOTT. *Jour. Soc. Glass Tech.*, **4**, 261–3.—The instrument consists of a thin-walled brass tube in which a rod carrying a cone at its lower end is free to move. A brass ring is soldered into the bottom and attached to this are three springy brass wires placed on radii which make angles of 120° with each other. These wires are all of the same length, and at the upper end of each a phosphor bronze ball is fixed. As the cone is pushed down the tube it comes into contact with the three balls, and presses them outwards as it descends. The tube is cut in order to allow the phosphor bronze balls and the wires attached to them to move freely in and out. When the instrument is placed with its lower end inside a glass tube, the cone can be pushed in until each ball is in contact with the inside of the glass tube, but when this happens the cone can descend no further. The diameter is then read off on the scale engraved on the rod. A ferrule is made so as to be a spring fit on the outside of the tube. This facilitates the measurement of internal diameters at any desired distance from the end of the tube to be measured. The instrument is graduated and calibrated by the aid of standard ring gauges.

E. RODGERS.

PATENTS

Furnace for melting glass and other purposes. JOHN SCHOFIELD SHAW. U. S. 1,359,756, Nov. 23, 1920. A furnace for melting glass and other materials in which a regenerator for the air is dispensed with. A bath for receiving the material to be melted is arranged in the interior of the furnace having a combustion chamber above it, two sets of longitudinal flues arranged on different levels below the bath and one air flue longitudinally arranged above the bath. One of the lower sets of flues is employed for the admission and heating of the cold air by the radiation of the heat from the bottom of the bath during its passage from the outside of the furnace to the combustion chamber, the other set is employed for conveying the waste gases and products of combustion from the rear end of the combustion chamber. The incoming air and the waste gases are arranged to travel in opposite directions. Two

vertical flues are provided at the rear of the furnace for respectively connecting the lower air inlet flues with the upper longitudinal flue, and with the rear of the furnace. Provision is made for a number of passages for connecting the upper longitudinal flue to the combustion chamber, and for a gas chamber connected by a number of passages to the combustion chamber for conveying the gas to the chamber for combustion purposes.

Glass-cutting frame. FRANK C. REMSBERG. U. S. 1,357,474, Nov. 2, 1920. A glass cutting frame comprised of oblong pieces arranged in a plane, additional pieces crossing the first mentioned pieces and secured thereto, the pieces forming a substantially quadrilateral, lattice-like frame, and stops foldably mounted on the frame adjacent an edge of the frame for abutment by a straight edge.

Device for severing glass. HARRY F. HITNER. U. S. 1,359,172, Nov. 16, 1920. In a glass cracking off device, a heating chamber, a reel in the chamber, a flexible cracking off member wound on the reel and adapted to be withdrawn from the chamber and means for heating the chamber.

Method of and apparatus for making sheet glass. THOMAS S. OWENS. U. S. 1,358,390, Nov. 9, 1920. The method consists in drawing a sheet of glass continuously upward through the air from a pool of molten glass, with the surface of the sheet free from contact with extraneous material until a glaze has formed thereon, bending the sheet over a roll having a surface which will not mar the glass, and maintaining a sliding contact between the surfaces by rotation of the roll. C. M. SAEGER, JR.

Enamels

The use of zinc sulphide for white and luminous enamels. J. SCHAEFER. *Taschenbuch für Keramiker, Keram. Rundschau,* 29–35 (1919).—Owing to the high cost of SnO_2 as an opacifier for enamel, substitutes for this are important. The use of zinc sulphide (German patent 289,317) has attracted considerable attention because it is comparatively cheap. A series of experiments were run to determine if zinc sulphide or zinc oxide produced opacity in enamels. A very fusible enamel was used containing about 5 per cent cryolite and the enamel was fired at 800° C. In experiment (1) 5 per cent ZnS and 6 per cent clay were added to the mill. A opaque glaze was obtained with a yellowish tinge probably due to the Fe in the sulphide. In experiment (2) 4.1 ZnO and 6 per cent clay were added. This enamel did not cover well showing that ZnS and not ZnO is necessary to produce opacity. Another series of experiments showed that ZnS is not destroyed in less fusible glazes unless certain metals which have a strong affinity for Zn are present. The more refractory enamels containing ZnS however are not as glossy as the same containing SnO_2. A number of patents have been granted for making luminous enamels with luminous ZnS since the chem. compos. is not very different from that of pure ZnS. Luminous ZnS (*i. e.*, radio active ZnS) has

been used for some time with transparent varnish for various instruments. The disadvantage of using varnish as a binder is that the radioactivity of the paint has only a short life, being practically gone at the end of 3 yrs. whereas luminous enamels would probably last 10 yrs. It is necessary that 40–50 per cent luminous ZnS be added to an enamel to produce sufficient luminosity in the dark and for this purpose a very fusible enamel seems best suited. Enamels containing ZnS can not be used to make colored enamels since the coloring oxide would combine with the ZnS producing poor colors.

H. G. SCHURECHT.

Whiteware and Porcelain

Firing hard porcelain with wood gas. M. LARCHEVÉQUE. *Ceramique*, **23**, 73–7 (1920); *Keram. Rundschau*, **28**, 389–90, 401–2 (1920).—Owing to the fuel shortage in Europe experiments were run to determine if gas generated from wood could be used to fire hard porcelain. It was found that it was easy to reach the necessary temp. and that porcelain as well as other ceramic wares can be fired with wood gas. Wood gas has the advantage in that it contains no sulphur and ashes and hence most of the ware may be set in the open fire. The best woods for this purpose are oak, birch and beech.

H. G. SCHURECHT.

The physical properties of whiteware glazes. R. RIEKE. *Ber. der Tech. wiss. Abt. des Verb. keram. Gewerke*, **5**, 8–15 (1919).—In general it might be said that crazing of glazes is due to a difference in the coeff. of expansion of the glaze and body. Although a high elasticity and tensile strength may prevent crazing where the expansion of the body and glaze are different, such glazes are not very durable as they often craze after a long time. For hard-burned porcelains and porcelain glazes the expansion increases uniformly with an increase in temp. The coeff. of expansion of Berlin tech. porcelain at 700° is 35×10^{-7}, while porcelain glazes vary from 27×10^{-7} to 42×10^{-7}. It is possible, therefore, to pick glazes which have the same coeff. of expansion as porcelain. With stoneware it is impossible to get a glaze which expands and contracts the same as the body, since stoneware bodies always contain considerable free silica. Cristobalite shows a sudden change in vol. at 200°. Since even low melting glazes are no longer soft at 200°, the stoneware in contracting suddenly at this temp. on cooling causes cracks in the body or glaze. Furthermore, with glazes which harden above 500°, strains are produced owing to the conversion of α and β quartz at 575°. The coeff. of washed kaolin is about 40×10^{-7} to 80×10^{-7}. A stoneware containing 25 per cent flint and fired at cone 7 had a coeff. of expansion of 130×10^{-7} between 15° and 200°; 70×10^{-7} between 200° and 500°; 140×10^{-7} between 500° and 600° and 50×10^{-7} between 600° and 1000°. The coeff. of expansion of whiteware glazes varies between 57×10^{-7} and 96×10^{-7}. It is therefore impossible to fit a glaze to a stoneware body with such varying expansions. The modulus of elasticity of a glaze varies between 5700 and 6800 kg./sq. mm., which is a very small range. It may be said, therefore, that

the coeff. of expansion of glazes may be varied between comparatively wide limits by means of their chem. compn., but the modulus of elasticity can be varied but slightly by this method. The tensile strengths of most whiteware glazes probably lies between 5 and 8 kg./sq. mm., although some are as low as 3.5 kg./sq. mm. Of the above properties the coeff. of expansion is the most important. The tensile strength is more important than the modulus of elasticity. If two glazes have a modulus of elasticity of 5000 and 7000 kg./sq. mm., respectively, and a tensile strength of 5 kg./sq. mm., a rod of 10 cm. long would be expanded 0.10 mm. and 0.07 mm., resp., with a load of 5 kg./sq. mm. If the tensile strength is 8 kg./sq. mm. and the max. tension applied the expansion would be 0.17 mm. and 0.11 mm., resp., for the glazes with different moduli of elasticity. [*C. A.*]

Porcelain money. ANON. *Keram. Rundschau*, **28**, 435–7 (1920).—Porcelain money is now being substituted for the more unsanitary paper money in Germany. To make this money a good bond clay together with a more refractory clay is used. The clays should be hand picked and free from pyrites. The grog is made of well sintered clay. The body should show no black spots or swelling when fired to 1400° C and should have a wide vitrification range. H. G. SCHURECHT.

The testing of chem. porcelain in England. J. GR. *Keram. Rundschau*, **28**, 470–1 (1920).—To determine the defects the ware is soaked in 5 per cent eosin sol. for 18 hrs. By this means defects such as crazing, pinholes, porous bodies, etc., may be detected. The vessel is then washed in HCl and dried. Its resist. to sudden temp. changes is then measured. This is done by heating the vessel with a Bunsen burner, removing from the flame with a cold pair of tongs and placing on a cold porcelain triangle 6 times. The ware is then soaked for 12 hrs. in eosin sol. and examd. for defects. If no defects appear the vessel is subjected to six more heats. The resist. to high temps. is measured by heating to 950° C, at which temp. the glaze should show no signs of blistering or running. In the cleaning and wet heating test a dry vessel is heated to red heat, cooled and weighed. It is put in hot dil. acid (1 part conc. HCl and 1 part H_2O) for 12 hrs. It is then washed, dried with a towel and immediately put over a burner and heated to red heat. Upon cooling the weight should be the same as it was originally and the vessel should show no defects after soaking in eosin sol. To test the resist. to acids and alkalies the weighed vessel is filled with conc. HCl and heated over a water bath for 4 hrs. It is then reweighed. This same treatment is repeated using a 5 per cent Na_2CO_3 sol. and a 5 per cent NaOH sol. To roughly test the lead content in the glaze a drop of HF is applied to the glazed surface. The acid is evaporated by placing the dish over a steam bath and is then covered with a drop of H_2SO_4. A brown or black spot indicates lead, copper, etc., and should not appear on first-class ware. Lead or other reducible oxides may be also detected by heating to a red heat and passing a stream of H over same. If reducible the glaze will darken. H. G. SCHURECHT.

Cone 7–9 porcelains. TH. HERTWIG-MÖHRENBACH. *Sprechsaal*, **53**, 363–5 (1920).—Owing to the fuel shortage cone 7–9 porcelains are being substituted for the more fuel consuming cone 14 porcelains. Cone 7 porcelains vary in composition between the following limits:

$$\left.\begin{matrix}0.5\ K_2O\\ .5\ CaO\end{matrix}\right\} 1Al_2O_3 5SiO_2\ \text{(Pukall) to}\ \left.\begin{matrix}0.65\ K_2O\\ .35\ CaO\end{matrix}\right\} \begin{matrix}1.97Al_2O_3\ 11.68SiO_2\\ \text{(Dorfner)}\end{matrix}$$

Cone 9 porcelains vary between the following limits:
(*a*) RO $3Al_2O_3$ 14.45 SiO_2 to (*b*) RO 4.8 Al_2O_3 27 SiO_2
(*a*) This porcelain is very pretty but not very translucent. (*b*) This porcelain is very translucent. In France porcelains of the *a* type are fired at cone 14 at which temp. they become very translucent. A French body which matures at cone 9 is as follows:

$$\left.\begin{matrix}0.8\ K_2O\\ .2\ CaO\end{matrix}\right\} 2.78Al_2O_3 12.74SiO_2$$

A Thuringian manufacturer makes a porcelain similar to type *b* which is fired at cone 9. Some well known Silesian and Bavarian manufactures use the following body which is fired at cone 9: RO $4Al_2O_3 18.7SiO_2$. If this body is ground for 24 hrs. at 23 r. p. m. it matures at cone 9. All German hard porcelains mature at cone 9 if ground for 100 hrs. It is obvious that the SiO_2 and Al_2O_3 contents are not as important as one may think. A body of the following composition together with a little ZnO_2 makes an excellent porcelain at cone 9:

$$\left.\begin{matrix}0.75\ K_2O\\ .25\ CaO\end{matrix}\right\} 3.5Al_2O_3 18.0SiO_2$$

One body of the composition RO 3.6 Al_2O_3 18.5 SiO_2 has a shrinkage of 10.6 per cent at cone 9 and was found very satisfactory for doll heads. The lower the acid content the better the porcelains stand up in firing. Glazes for cone 7 and 9 are as follows:

$$\text{Cone 7}\ \left.\begin{matrix}0.2\ K_2O\\ .2\ MgO\\ .6\ CaO\end{matrix}\right\} 0.4Al_2O_3 3.5SiO_2\quad \text{cone 9}\ \left.\begin{matrix}0.2\ K_2O\\ .2\ MgO\\ .6\ CaO\end{matrix}\right\} 0.5Al_2O_3 4SiO_2.$$

Both of these glazes develop excellent greens which is impossible with cone 13 glazes. In firing colored glazes it is important to fire oxidizing. The following glaze develops a beautiful Victoria green:

$$\left.\begin{matrix}0.4\ PbO\\ .45\ CaO\\ .15\ K_2O\end{matrix}\right\} 0.32Al_2O_3\ 2.95SiO_2.$$

In Thuringia the bodies are ground for 70–100 hrs. For glazing this ware hard tough glazes are required to prevent crazing. The bodies ground for 24 hrs. can be covered with softer glazes. Flint should be used in the place of quartz since it is much purer. The following bodies were found very promising for cone 7 porcelains, some having a very low shrink.

1.	0.5 K_2O .5 CaO	$2Al_2O_3 10SiO_2$	9.	0.5 K_2O .5 CaO	$2Al_2O_3 9SiO_2$
2.	.5 K_2O .5 CaO	$1.9Al_2O_3 9.9SiO_2$	10.	.63K_2O .37CaO	$2.3Al_2O_3 9.59SiO_2$
3.	.5 K_2O .5 CaO	$1.8Al_2O_3 9.5SiO_2$	11.	.50K_2O .50CaO	$1.8Al_2O_3 7.5SiO_2$
4.	.8 K_2O .7 CaO	$1.84Al_2O_3 7.15SiO_2$	12.	.50K_2O .50CaO	$1.8Al_2O_3 8.48SiO_2$
5.	.65K_2O .35CaO	$2.41Al_2O_3 9.4SiO_2$	13.	.65K_2O .35CaO	$2Al_2O_3 9SiO_2$
6.	.50K_2O .50CaO	$1.6Al_2O_3 8SiO_2$	14.	.50K_2O .50CaO	$1.6Al_2O_3 7SiO_2$
7.	.50K_2O .50CaO	$1.7Al_2O_3 8SiO_2$	15.	.50K_2O .50CaO	$1.5Al_2O_3 7SiO_2$
8.	.50K_2O .50CaO	$1.9Al_2O_3 8.8SiO_2$	16.	.50K_2O .50CaO	$2Al_2O_3 11SiO_2$

H. G. SCHURECHT.

Is Swedish quartz replacable by German sandstone in the manuf. of porcelain? ANON. *Sprechsaal,* **28,** 402, 412–3 (1920).—In Germany there are a number of sandstones which contain over 95.5 per cent SiO_2 and less than 0.05 per cent Fe_2O_3. This sand is used in the manuf. of high grade mirror and optical glass. It was found that the Swedish quartz has about the same SiO_2 as the sand and contains more Fe_2O_3 than the sand. In literature it is claimed that porcelains prepared with quartz sand have a gray color. Since this sand is purer than the Swedish quartz this color must be due to different optical properties of the sand which impart a grayish tinge instead of a white tinge as is obtained when Swedish quartz is used. Rieke and Endell (*Silikat-Z.*, **48,** 1920) found that upon firing Norwegian quartz once its sp. gr. was decreased from 2.65 to 2.38, while for Hohenbacher sand it was only decreased to 2.591 and only after firing 11 times was its sp. gr. decreased to 2.328.

H. G. SCHURECHT.

Brick and Tile

Requirements of quartz brick and mortar in England. ANON. *Keram. Rundschau,* **28,** 402–3 (1920).—The brick should contain not less than 94 per cent SiO_2 or more than 2 per cent CaO. The fusion should be cone 30 or better. Upon heating to cone 12 the brick should not show an expans. greater than 0.75 per cent. The quartz mortar should be finely ground and contain not less than 92 per cent SiO_2 and fuse at a temp. equal to that of the brick.

H. G. SCHURECHT.

New selling methods in brick industry proposed. ANON. *Chem. Met. Eng.,* **23,** 1038.—A new card of price extras has been adopted by a number of leading producers of fire-clay and silica brick. Shapes are classified according to cost of manufacture and each class takes a percentage extra over the

base price. Thus the extra charge on any class of shapes automatically changes with any change in the base price. A large number of the shapes in common use have been classified according to the cost of production and it is expected that as further cost figures are obtained a complete list of all shapes in general use can be prepared. A. J. LAMBERT.

PATENTS

Brick machine. OLAF BRATNESS. U. S. 1,358,925, Nov. 16, 1920. A machine having a fixed mold and fixed end plate and a movable end plate, a rock-shaft to which the movable end plate is secured, a bottom plate for the mold secured to the rock-shaft, the rock-shaft being mounted for raising and lowering movement, a foot lever and lazy-tongs connecting the foot lever for raising and the rock-shaft.

Wall for brick-kilns. HALVER R. STRAIGHT. U. S. 1,360,245, Nov. 23, 1920. A kiln wall, formed of an inner and outer wall and a loose yielding filler between them, the inner wall being formed of a series of loosely laid bricks having their outer ends pointed or beveled, the bricks being laid in staggered relation, relative to each other, and the outer wall being formed solid. C. M. SAEGER, JR.

Cement and Lime

Manufacture of lime for chemical and metallurgical purposes. II. R. K. MEADE. *Chem. Met. Eng.*, **23,** 873–5; **III, 23,** 929–32.—A description of the applications of rotary lime kilns in burning stone and recovering spent lime. The advantages are great capacity, low labor and operations costs and utilization of spalls. Pulverized coal, producer gas, natural gas and oil are employed for heating rotary limekilns. The fuel requirements of a rotary kiln are from 2800 to 3500 B.t.u. or 400 to 500 lbs. of coal per ton of lime, 37 to 45 gal. of oil per ton of lime, 500,000 to 625,000 cu. ft. of natural gas per ton of lime. Pulverized coal and producer gas are the fuels commonly available. The advantages of pulverized coal over producer gas are: (1) more uniform rate of supply of fuel to the furnace and fuel of more uniform quality; (2) with powdered coal the loss due to carbon remaining in the ash is avoided; (3) it is possible to burn powdered coal with almost the exact quantity of air necessary for combustion, which is not possible with producer gas; (4) elimination of loss due to radiation of heat from the producer and piping system in manufacturing producer gas. The cost of gasifying a ton of coal in a mechanically stoked producer is $1.09. The cost of pulverizing a ton of coal is $0.71. The power required to operate a rotary kiln plant per ton of lime produced where pulverized coal is used is about 16 h. p. The cost of a rotary kiln lime plant of the best construction will be approximately $950 per ton of lime produced per day. The cost of producing lime in a rotary kiln plant in the middle eastern states at this time varies from $3.25 to $5.40. The waste gases, which leave the kiln at about 1300°F, can be used for heating boilers. A. J. LAMBERT.

Portland cement specifications. ANON. *Brit. Clayworker*, **29**, 27 (1920). —Brit. standard specifications for Portland cement, Report 12, 1920 contains a number of important modifications. (1) A paragraph has been inserted making clear that no cement to which slag has been added, or which is a mixture of Portland cement and slag, will comply with the specifications. (2) Provision has been made for sampling cement when stored in deep silos. (3) The sp. gr. test has been eliminated. (4) The aeration of cement before testing for setting time has been dispensed with. (5) A provision has been inserted permitting the deduction from the total lime content of the proportion of lime necessary to combine with the sulphuric anhydride present when calculating the lime ratio. (6) The medium and slow setting cements have been replaced by a grade having a minimum initial setting time of 20 mins., and a maximum final setting time of 10 hrs. A minimum final setting time is not now specified. (7) The clause relating to the supply by the vendor, free of cost, of a certificate that the cement has been tested and analyzed and complies in all respects with the specifications, has been modified to provide that if such a certificate is required it must be so specified at the time of purchase. It is stipulated that samples for testing are to be taken from 12 different positions of a heap or from 12 different bags. Six tests are required to be carried out whose results should comply with the following conditions: (*a*) *Fineness.*—100 g. are sifted for 15 min. on each of the following sieves: (1) 180 × 180 mesh, to leave a residue not to exceed 14 per cent. (2) 76 × 76 mesh, with not more than 1 per cent residue. (*b*) *Chem. Analysis.*—Insoluble residue not to exceed 1.5 per cent; magnesia, 3 per cent; and total S calculated as sulphuric anhydride, 2.75 per cent. The total loss on ignit. to be less than 3 per cent. (*c*) *Tens. strength* (*neat cement*).—Test briquettes to be kept damp for 24 hrs. after gauging, after which they are to be removed from molds and submerged in fresh water at a temp. of 58–64°F 6 briquettes to be tested for breaking strength at 7 and 28 days respectively. After 7 days breaking strength not to be less than 450 lbs. per sq. in. section, and an increase to be shown at 28 days and not to be less than that calculated by the following formula:

$$\text{Breaking strength at 7 days} + \frac{40{,}000}{\text{Breaking strength at 7 days}}.$$

(*d*) *Tens. strength* (*cement and sand*).—Briquettes to be in proportion of 1 part of cement to 3 parts of standard sand, each by weight. Conditions for setting are the same as for neat cement. Breaking strength at the end of 7 days to be not less than 200 lbs. per sq. in. section. For 28 days breaking strength to comply with conditions similar to neat cement. (*e*) *Setting time.* —Initial setting time to be not less than 20 min. and final setting time no more than 10 hrs. These times are to be determined by Vicat needle apparatus. (*f*) *Soundness.*—This is to be tested for by the Le Chatelier method. The expans. is not to exceed 10 mm. after 24 hrs. treatment. After 7 days it shall not exceed 5 mm. H. G. SCHURECHT.

ACTIVITIES OF THE SOCIETY

Actions of the Board of Trustees

December 10. It was voted that the price of the Collective Index to the Transactions be $1.50 postpaid.

December 10. It was voted that Dr. E. W. Washburn be appointed Editor of the Journal for 1921, at a salary of $125.00 a month.

December 28. A provisional draft of By-Laws for any Division of the Society, recommended by the Committee on Rules, was approved by the Board.

December 28. It was voted to allow the Enamel Division the sum of $20.00–$25.00, in addition to the regular allottment, for the operations of the Division in a membership campaign.

New Members Received during December

Associate

Ahlswede, R. B., 1406 N. Spring St., Los Angeles, Cal., Secretary, California Metal Enameling Co.

Coates, William W., Jr., 313 East Springfield St., Champaign, Ill., Student, University of Illinois.

Kahn, Harry J., Zanesville, Ohio, Assistant to Director, American Encaustic Tiling Co.

Koupal, Walter G., Creighton, Pa., Pittsburgh Plate Glass Co.

Merritt, L. M., 586 E. Long St., Columbus, Ohio, Ceramic Engineer, Barnebey-Cheney Engineering Co.

Post, Albert H., Waterville, Conn., Superintendent, Gordon Electric Manufacturing Co.

Powell, R. E., 8700 S. State St., Chicago, Ill., Chief Engineer, Federal Electric Co.

Slobodkin, S. H., 146 Condor St., East Boston, Mass., Boston Pottery Co., Inc.

Smith, R. G., Fort Worth, Texas, Plant Manager, Acme Brick Co.

Swope, H. J., Quincy, Ill., Business Manager, Economy Enameling Co.

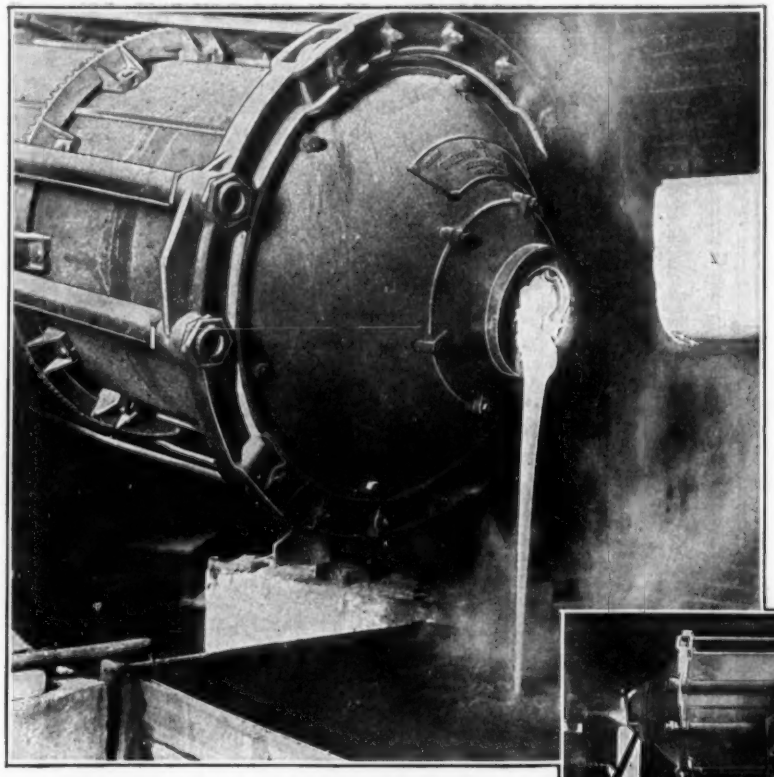
Taylor, R. P., Roseland, Nelson Co., Va., Superintendent, Klimax Kaolin Co.

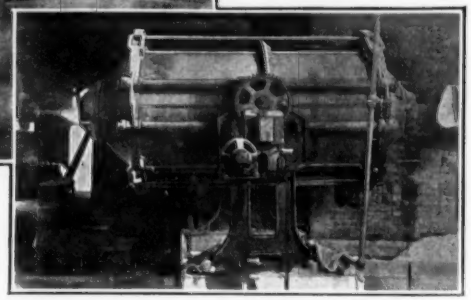
Corporation

Portland Stove Works, Portland, Oregon.

Mfg. Co., Beaver Falls, Pa.

U. S. SMELTING FURNACE CO.
BELLEVILLE, ILLINOIS





These illustrations made from photographs taken in the plant of Ingram-Richardson Mfg. Co., Beaver Falls, Pa.

"Our U. S. Enamel Furnaces Increase Output 25% per day at a Saving of 50% in Fuel Cost."

Ingram-Richardson Mfg. Company claim those remarkable results for their U. S. Enamel Furnaces. With four U. S. Furnaces operating at their plants at Frankfort, Indiana, and Beaver Falls, Pa., they are saving thousands of dollars yearly in fuel and labor.

Their white and colored enamels are smelted in quick time, with low loss. The work is easy and sure. The Furnace is under perfect scientific control. The melting process is visible. The Furnace rotates while melting and tilts when pouring. Linings last longer and cost less.

The U. S. Enamel Furnace is saving money over the old brick smelter in the Ingram-Richardson Mfg. Company plant. It will do the same for you.

Let the U. S. Furnace melt your enamel.

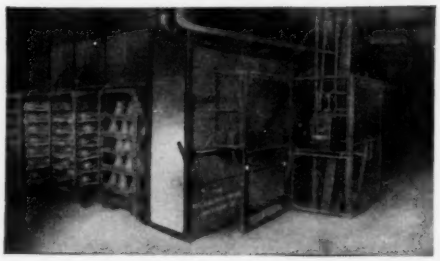
Write for specifications and prices on 60 lb., 150 lb., 400 lb., 750 lb., and 1200 lb. Enamel Furnaces. We will send photographs and list of users where furnaces are in operation.

THE
U. S. SMELTING FURNACE CO.
BELLEVILLE, ILLINOIS

"HURRICANE" DRYERS

For High Tension Electrical Insulators

Cut a week from the Manufacturing Schedule



Tunnel Truck Dryer for Insulators.

This is what is being accomplished in one of the largest insulator plants in the country.

Besides this saving in time, there are corresponding savings in the labor of handling, floorspace and in checked ware.

The Philadelphia Drying Machinery Co.

Main Office and Works
Stokley St. above Westmoreland

Philadelphia

Boston Office
53 State St.

TUNNEL KILNS

ZWERMANN PATENTED DESIGNS

SINGLE OR TWIN

ANY FUEL ANY WARE

FOR INFORMATION ADDRESS

RUSSELL ENGINEERING CO.

RAILWAY EXCHANGE BUILDING

ST. LOUIS, MO.

If you want the best, buy or specify
MONTGOMERY HARD PORCELAIN PYROMETER TUBES
All Sizes and Lengths for Either Rare or Base Metal Couples

1. Can be used to 1600 C–2900 F.
2. No glaze to stick or to be absorbed by a porous body.
3. Body vitreous and absolutely impervious to gases.
4. Notably resistant to sudden temperature changes.
5. Trade-marked for identification.
6. Made with or without collars or flanges.
7. Prices reasonable – – Deliveries quick.
8. Threaded brass couplings cemented to tubes if desired.
9. Sold direct from the factory or through the manufacturer of your Pyrometer Equipment.
10. Write us for quotation on tubes for replacement, stating the size tube you use and length.

TRADE MARK

MONTGOMERY PORCELAIN PRODUCTS CO.
Franklin, Ohio, U. S. A.

BRICK MAKING MACHINERY

OF THE STRONGER AND BETTER CLASS

We specialize on Dies and Augers and to their adaptation to individual requirements. Automatic Cutters up to 12000 bricks per hour Capacity.

CHAMBERS BROS. CO. Fifty-Second Street Corner of Media **Philadelphia, Pa.**

We Have Faith in Our Goods so We Advertise Here—

The Underwood Producer Gas System, patented, saves fuel and labor in burning clayware, baking carbon products, roasting ores, heating lehrs in glass factories, also revolving pots, etc., and enameling metal ware.

The Justice Radiated Heat and Waste Heat Dryers for drying structural clayware have no equal in economy and efficiency.

"Meco" Single Roll Rock and Shale Crushers, Elevators, conveyors, and feeders make up the most complete clay preparing outfit, a necessity in every clay plant when material must be ground and screened. Write us about these things. To answer is our pleasure.

THE MANUFACTURERS EQUIPMENT CO.

Dayton, Ohio, U. S. A.

ACID AND HEAT RESISTING MATERIAL

for

PLANT AND LABORATORY EQUIPMENT

Where chemical stoneware, glass or porcelain cannot be used on account of their large coefficient of expansion and consequent low resistance to sudden changes of temperature and where the use of platinum is impossible because of high price

FUSED SILICA

is the ideal material.

We manufacture all standardized shapes and sizes or to your own drawings.

ASK FOR OUR CATALOG No. 4.

GENERAL CERAMICS COMPANY

50 Church Street

NEW YORK CITY

HIGH GRADE MISSOURI FIRE CLAYS

ZINC SPELTER, GLASS HOUSE AND FURNACE CLAYS

Grand View Fire Clay Mines

A. A. Vancleave, Proprietor

Office and Mines: 5021 Fyler Avenue **St. Louis, Mo.**

WANTED

TRANSACTIONS OF THE AMERICAN CERAMIC SOCIETY

Volumes II, V, IX, X, XII, XIV, and XIX.

Five dollars will be paid for each copy in good condition.

Charles F. Binns, Secretary

Alfred, New York

THE ROESSLER & HASSLACHER CHEMICAL CO.

SERVICE

it obtained by securing our "A 1 PRODUCTS" that gives the satisfaction you are seeking.

The MERITS of our HIGH GRADE CHEMICALS have been recommended for the past forty years and continues to answer the demands.

Consistency on your part for the

A1

DURABLE, SUPERIOR & ECONOMICAL CHEMICALS

will strengthen your reputation.

Branches

New York	Cleveland	Cincinnati
Chicago	Philadelphia	Kansas City
Boston	Trenton	Akron
	San Francisco	

SIL-O-CEL

MADE FROM CELITE

Prevents heat radiation from walls and crowns of kilns—provides uniform temperatures and better control.

For Greater Fuel Economy

The answer is insulation—to prevent heat waste. Once you control your kiln temperatures—preventing its dissipation, you not only improve its uniformity but reduce excessive burning of fuel.

SIL-O-CEL brick answers every demand for kiln insulation. Write for Bulletin 5-A and see its application to kilns and other equipment.

CELITE PRODUCTS COMPANY

NEW YORK, 11 BROADWAY · CLEVELAND, GUARDIAN BLDG · ST. LOUIS, 1532 OLIVE STREET
PHILADELPHIA, LIBERTY BLDG · DETROIT, BOOK BUILDING · LOS ANGELES, VAN NUYS BLDG
PITTSBURGH, OLIVER BLDG · CHICAGO, MONADNOCK BLDG · SAN FRANCISCO, MONADNOCK BLDG

Quality *Uniformity* *Experience*

Edgar QUALITY *Clays*

REALLY washed—Highest percentage clay substance

Brands	*Produced by*
Edgar Florida Kaolin	*Edgar Plastic Kaolin Co.*
Edgar Georgia Paper Clay and Kaolin	*Edgar Brothers Co.*
Lake County Florida Clay	*Lake County Clay Co.*

One Management—Office, Metuchen, N. J.

NEW PRICES

TRANSACTIONS OF THE AMERICAN CERAMIC SOCIETY

The following volumes may be obtained singly:

Vol.	I	$4.75
"	III	4.75
"	VII	6.50
"	XIII	6.50
"	XVI	8.00
"	XVII	8.00

A complete set, minus Vols. IX, XII, and XIX which are out of print, may be obtained at a cost of $150.00, with 40% discount to members of the Society.

Charles F. Binns, Secretary
Alfred, New York

Glasgow Saved 1/3 Burning Time What Can You?

During the period from June 5 1919 to June 22 1920 we burned 83 kilns of brick. Our average burning time over this period was 7 days 12 hours.

Your Pyrometer installation was completed on June 25 1920. Since that time we have burned 31 kilns of brick. Our average burning time over this period was 5 days 5 hours.

With this saving of 2 days and 7 hours on the burning time there was necessarily a corresponding saving in fuel consumption and we have been able to turn out a more uniform product at the same time. Your instruments have given us satisfaction in every respect and our only regret is that we did not make the installation sooner.

Let us tell you how a Brown Pyrometer will save you money. Write for folder 11-1. Advise us of number and types of kilns.

The Brown Instrument Co. 4513 Wayne Ave. Phila., Pa.

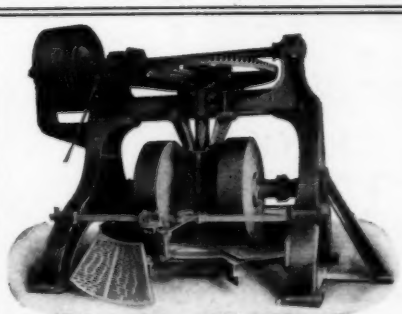
Brown Pyrometers

"Proctor" DRYERS

DRYING CERAMIC PRODUCTS

Porcelain and General Ware, Brick, Tile—any article made of Clay—can be dried by efficient, mechanical "Proctor" Dryers with results vastly superior, far more economical than the results of any other method. Write for our catalog—shows "Proctor" Dryers in leading plants and tells what they have accomplished.

Proctor & Schwartz, Inc., Philadelphia



American Nine Foot Dry Pan

Here's one of our famous line of pans. They are built to handle a lot of clay and they do it. Nothing shoddy about this pan, that's why it makes good and works steadily without trouble. Get our pan printed matter. We surely have a pan to do your work better and with less trouble and expense than you are now doing it. Let us prove it.

The American Clay Machinery Co.
Bucyrus, O.

If you have faith in your products, record them in this Journal

ENGLISH
AND
DOMESTIC

CLAYS
FOR
ALL
CERAMIC
PURPOSES

—PMCCO—
MEANS SERVICE, QUALITY AND PRICE

PAPER MAKERS CHEMICAL CO., EASTON, PA.

VITRO
CHEMICALS

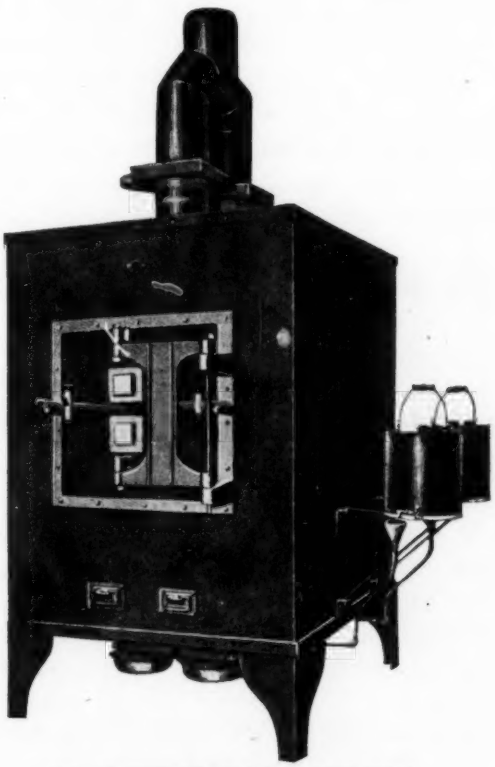
SELENITE of SODIUM
ARTIFICIAL CRYOLITE
for white and opalescent glass
SODIUM SILICO FLUORIDE
UNDERGLAZE COLORS
for high temperatures
POTTERY GLAZES & ENAMELS

The Vitro Mfg. Co. Pittsburgh, Pa.

PERFECTION POTTERY KILNS

FOR FIRING BUSCUIT, CLAY BODIES AND GLAZES

EQUIPPED FOR KEROSENE OIL,
MANUFACTURED AND NATURAL GAS



NO. 12 PERFECTION POTTERY KILN
Equipped With Kerosene Oil Burners

B. F. DRAKENFELD & CO., Inc.

50 MURRAY STREET NEW YORK, N. Y.

ILLUSTRATED CATALOG MAILED ON REQUEST

"BRICKS WITHOUT STRAW!"

This demand of the ancient Egyptians on the captive children of Israel was no more unreasonable than that of the brick manufacturer who used to ask his men to make bricks without Pyrometers.

Fortunately such men are scarce. Give economic laws a little time to act and they will become as extinct as the dodo. They cannot compete with the man who has a shorter burn, fewer "seconds" and uses less fuel. Pyrometer equipment means lower costs and more productive kilns.

ENGELHARD PYROMETERS

have done good work increasing profits in brick plants. They are simple, accurate, and what is more important, *you can depend on them*. More and more brick makers are turning to Engelhard Equipment as the solution of their Pyrometer troubles just because of these qualities. Some of the largest ceramic industries have made them standard equipment. Experience has shown them that

ENGELHARD PYROMETERS ARE GOOD PYROMETERS TO STANDARDIZE ON

Our catalog tells the whole story. Write for it.

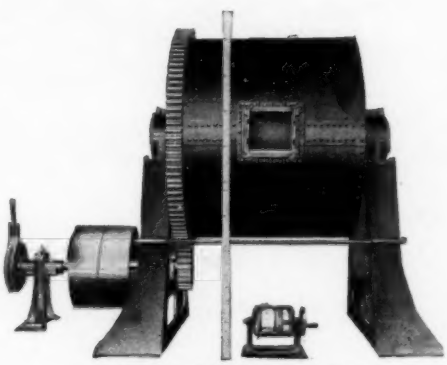
CHARLES ENGELHARD

30 Church Street **New York City**

ABBÉ
ENGINEERING CO.

BALL AND PEBBLE MILLS

A SIZE FOR EVERY NEED



Abbé Pebble Mill (Patented)

59 SIZES—20 DESIGNS
Over 100 Machines in Stock.

WE ALSO MANUFACTURE
DISINTEGRATORS—FILTER PRESSES—VACUUM PUMPS

SEND FOR BULLETINS

ABBÉ ENGINEERING COMPANY

Telephone
Cort. 54-55-56

1112 St. Paul Building
New York

Works
Brooklyn, N. Y.

PLASTIC ZIRCON FIRE CEMENT

Softens above 3200° F.
Bonds at low temperatures.
Mechanically stronger than fire brick.
Works easily---is not sticky, shipped dry.

Contains no silicate of soda, caustics,
fire clay, or organic binders.

Price 6c per pound in less than ton lots---
f. o. b. Plant, sacks extra.

Send for some today for your refractory problems.

BUCKMAN & PRITCHARD, INC.

MINERS AND MANUFACTURERS

MINERAL CITY, FLORIDA

New York Office, 94 Fulton Street

Chicago Office, Peoples Gas Building

HF&G

HF&G TIN OXIDE

THE HARSHAW FULLER AND GOODWIN CO.

Cleveland

Chicago New York Philadelphia

Nothing but scientifically applied electric power can bring out the full effectiveness of men or machines—so badly needed today

G-E Vertical Motor for direct drive for centrifugals or pumps

Now industry is adding conservation to production

INDUSTRY throbs with a new energy—the energy to produce, *plus* the energy to conserve.

And as inventions shape the gifts of earth to man's needs, they use power—power made, distributed and used effectively to conserve coal and labor.

For in these times of peace, production must go on; though its cost must be lessened.

* * *

In determining the kind of motors and control which do this great work, there are factors of vital importance. With these factors in mind, G-E engineering specialists co-operate with any concern in finding the way to greater production at lower cost.

In the case of E. I. du Pont de Nemours & Company special motors were found right, and they were built quickly. They increased production and reduced manufacturing cost.

Readiness to serve, and ability to produce just the right electric power equipment, await every user of any kind of power.

GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

Look for this mark of leadership in electrical development and manufacture

43-220

G-E motors

From the Mightiest to the Tiniest

GENERAL ELECTRIC COMPANY